The Perception of Causality

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A. Michotte

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Originally published under the title
La Perception de la Causalité
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Foreword by R. C. Oldfield, M.A.(Cantab.),
Professor of Psychology, University of Oxford
Commentary by T. R. Miles, M.A.(Oxon),
Lecturer in Psychology, University College, Bangor
English translation by T. R. Miles, M.A.(Oxon)
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Foreword

Visitors to Professor Michotte's laboratory – since the last war alone they must have been numbered by the hundred – get the best opportunity there can be of grasping the essence of his work. Perhaps not all visits to laboratories are as profitable as some visitors seem to think. But anyone fortunate enough to go to Louvain finds himself welcomed by a family which has all manner of exciting things going on. He arrives a guest but soon becomes a participant. Unfortunately not everybody can get to Louvain. Some who have not been able to, have heard, if briefly, about Professor Michotte's experiments from his lectures at international meetings, and through his visits to other laboratories. Even so there must be many whose acquaintance is at second-hand. For these, as for those already acquainted who wish to study his work in more detail and at greater leisure, the published account is indispensable. It must be admitted at once that this is not an easy text, and to some people may have seemed the more forbidding through being written in French. For this reason people in psychological laboratories almost everywhere ought to be extremely grateful to Tim and Elaine Miles, who undertook the very difficult and arduous task of producing an accurate and scholarly translation. To do so needed a mastery of special topics ranging from the calibration of rotating apparatus to seventeenth-century philosophy. Their qualifications – Mr Miles is a psychologist whose competence in philosophy is at a professional level: Mrs Miles' university studies were in languages – and their conscientiousness are a guarantee that this version is not the product of hasty enthusiasm and incomplete grasp of substance and context, but will stand the test of time.

Michotte's approach to psychological problems is an individual one, and readers to whom it is new may perhaps be helped by a brief sketch of the sequence of influences and interests which led him to undertake the experimental study of the perception of causality which is the subject of this book.[1] After a distinguished career as a student, first in

[1] I have drawn largely on Professor MICHOTTE'S *Autobiographie* (Editions Nauwelaerts, Louvain, 1954), a somewhat amplified French version of the contribution which appeared in *A History of Psychology in Autobiography*, Vol. III, Clark University Press, 1952. But I am specially grateful to Professor Michotte, who has himself amplified certain points in private correspondence.

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evidence for a conclusion which hitherto he had been able to support only by appeal to general Gestalt principles. Choosing a very simple action, that of one thing hitting another and setting it in motion, he devised the remarkably elegant method of presenting this situation to the subject by the rotation of a disc, bearing appropriately painted coloured stripes, behind a slit. He thereby achieved effective and flexible control of the time, position, and velocity parameters, and in the facilities it offers for innumerable experiments the apparatus deserves to rank among the classics of psychological instrumentation. The very fact, too, that in a sense the objects which appear to move and to collide are not real objects at all adds a further touch of piquant interest – an interest which perhaps has not yet been exhausted.

The reader must be left to enjoy the story of how, in a series of experiments perhaps unmatched in the history of psychology for their simple forcefulness and sustained collected march, Michotte uncovered the characteristics and conditions of a variety of types of perceptual event which in the less analytic mood of everyday life we lump together under the heading of 'causal phenomena'. His cardinal finding, namely that the impression of causality is dependent on specific and narrowly limited spatio-temporal features of the event observed, is clearly of fundamental importance. We do not, according to Michotte, see one billiard ball cause another to move *either* because we intuitively apprehend a fact of nature, *or* because past experience leads us to see the event in this fashion, but because the spatio-temporal organisation is such that it directly unleashes this impression in us. Alter the relevant variables by a small but measurable amount and the impression disappears. But as the story develops it cannot be denied that difficulties intrude. And the conclusion to which it is brought by this book, first published in 1946, was, as anyone who knows Professor Michotte would expect, but the starting-point for exploration of fresh ideas aroused by it. To both the difficulties and the new findings Michotte attaches great importance. If I add some comment about them, I do so in the hope that, inadequate as it is bound to be, it will not be misleading or wholly unhelpful.

philosophy, then in biology – his first research publications were in the micro-anatomy of the nervous system – he paid an extended visit to Wundt's laboratory. Perusal of some of Binet's writings, however, suggested to him that the work of Wundt, 'though admirable, was insufficient', and 1907–8 found him at Würzburg. Returning to Louvain, he continued his task of building up the psychological laboratory, in which he was much encouraged and effectively supported by Cardinal Mercier. But he was able to combine this with sustained experiment on memory, especially that form of it in which logical structure plays a part. This phase came to an end with the First World War. Not long after the end of it, he tells us, appreciation of the cogency of at least some aspects of the behaviourist argument, together with criticisms levelled by Wundt, Titchener, and others at the Würzburg School, disrupted his confidence in an approach which leaned as heavily and essentially on introspection as did that of Külpe's associates. From then on his experimental work came to rely on subjects' introspective reports only as regards the presence or absence of an impression or phenomenon. Even this resource he eschewed in the work he carried out during the nineteen twenties. In his studies of movement during this time his outstanding flair for mechanical design, which later so largely contributed to the success of his work on causality, first found extensive scope. Careful recording of the movements made by a limb in a simple task, both before and after practice, allowed Michotte to demonstrate the tendency for motor patterns to take on progressively simpler and more organised forms as skill develops, and in several investigations he emphasised a number of similarities to the *Gestalten* which were at the same time being studied in the field of perception. After the International Congress at Oxford in 1923, where he had become acquainted with Köhler and Koffka, Michotte had, he tells us, become vividly interested in Gestalt principles. He soon became convinced that these principles apply not only to static forms, to motor patterns and to simple instances of apparent movement such as the phi phenomenon, but also to many instances of complex perceived movement. He was led to meditate, for example, upon the nature of what we see when we watch a man operating a machine or using a tool, and concluded that in such a case the complex of objects and movements forms a whole having specific properties of its own in the same way as, for example, a square is something specifically different from its four sides.

By 1940 Michotte had become anxious to obtain direct experimental

further exploration, not only of the conditions in which ampliation is and is not manifest, but also of what, to me at any rate, is an outstanding paradox, namely that impressions of causality in natural events do not always tally as regards their constitutive conditions with artificial ones in the laboratory. Each, as perceived, has only phenomenal status, and it is difficult to understand why ampliation is not equally and correspondingly a constituent of both.

Another fascinating and challenging conception, which has arisen particularly in the work undertaken by Michotte and his associates since this book was completed, is that of *amodal perception.*[2] Pursuing his experimental analysis of different types of mechanical phenomena, he tried to produce the impression of one object *compressing* itself by moving up against another – stationary – one. When the leading edge of the moving object reaches the stationary, its trailing edge continues to move, and it thus grows shorter along the line of its motion. To Michotte's considerable surprise there was no impression of compression at all. Instead, there was an absolutely compelling impression that the moving body retains its original size and moves behind the stationary one as if it were passing behind a screen. An effect quite bizarre is, indeed, produced if the stationary object is omitted from the experiment, while the first goes through the same evolution as before. In this case a slit is seen apparently to open in the background, through which the moving object passes and disappears. A third striking instance of this kind is the 'Tunnel Effect', in which an object, disappearing behind one edge of a stationary object, reappears from the other. If the time interval is longer than would be appropriate to the object's steady passage through the tunnel, there is a most striking impression that the object *halts* inside. This kind of perception, in which the total situation presented includes features which lack any specific sensory determination, and to which in the nature of the case there can be no corresponding physical stimulus, Michotte calls *amodal.* Gaps or 'holes' in the modal sensory pattern acquire, so to speak, a status equal to that of actual sensations modally determined. The situation is not quite like that of the phi phenomenon, or even the completion of a figure part of which falls in a blind part of the visual field, for in both these cases the com-

[2] *Vide* e.g. A. MICHOTTE, and L. BURKE, *Proc. XIIIth Int. Cong. Psychol.*, 1951, 179–80. L. BURKE, *Quart. J. Exp. Psychol.*, 1952, 4, 121–38. A. GLYNN, *Quart. J. Exp. Psychol.*, 1954, 6, 125–39. A. C. SAMPAÏO, *La translation des objets comme facteur de leur permanence phénoménale*, Louvain, 1943.

atory by corresponding selection of parameters? Are there instances, on the other hand, where an artificial event in the laboratory gives rise to an impression of causal action while a similar concatenation of moving bodies in the real world does not? In fact, both these contingencies arise. Michotte calls the former *negative*, and the latter *paradoxical* cases. By way of clarifying this situation he introduces an idea, which has other applications as well, which some people may find as difficult as it is interesting. This is the concept of *ampliation of the movement* (Chapter XIV). When, for instance, in the Launching Effect there is an impression of causality in the way object A sets object B in motion, this, Michotte holds, is dependent on the condition that, phenomenally, A's motion is *extended on to* and *partaken of* by B, quite apart from the *de facto* displacement which B suffers as a result of the collision. This extension of motion from the dominant on to the secondary object, and its appearance as a quality of the latter, is what Michotte means by *ampliation*. And he is able to distinguish in terms of the position, directions, times and velocities those cases in which it can be manifest from those in which it cannot. He is thus enabled to give an account of the negative and paradoxical cases and to clarify, in terms of the concept, that 'productive' aspect of causal events which has often been emphasised by those concerned with their phenomenology. But the concept of ampliation itself ought to give rise to some interesting discussion, for its status is unquestionably a peculiar one. On the one hand, ampliation does not seem to be directly apparent as such in experience, but seems rather to be an underlying condition that an experience should possess a certain character. On the other hand, if it is not immediately given in experience, it is difficult to see from where it derives status and explanatory power. My own suggestion about this difficulty (though whether it would appeal to Professor Michotte I do not know) would be that the status of the concept of ampliation is somewhat akin to that of 'good continuation' or of 'common fate' in relation to static forms. 'Good continuation' is not, in one sense, given immediately in experience, but we can discern it when its character is conveyed to us by someone else. And according to its presence or absence in a particular figure we are enabled to predict that this figure will have this or that other property, such, for instance, as prominence in a complex perceptual field or resistance to mnemic decay. The concept of ampliation seems to me to have much the same kind of status. It would be out of place to argue here the general case for and against concepts of this kind. But there would seem to be scope for

'I have always tried to gather data as well-founded as possible, that could provide a basis for general syntheses which, it seems to me, ought to be reserved for the future, and perhaps for minds more so inclined than mine.'

R. C. OLDFIELD

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pletion appears in the guise of a modally determined, namely visual, element. Some people may prefer to avoid reference to anything so apparently self-contradictory as amodal perception, and to couch their analysis of the phenomenal fact in terms of the known constructive tendencies of perceptual function. But Michotte's formulation has at least the merit of bringing clearly to our notice the degree and manner in which much of our everyday awareness of objects as *permanent* and *real* is dependent upon elements to which no physical stimulus corresponds at the time. This fact, whatever its proper provisional interpretation, deserves far more experimental study than it has yet been given.

Concern with these problems has latterly led Michotte and his students to a more general enquiry into the conditions in which things appear as *real*,[3] and to ask what features of a stimulus pattern need to be present in order that a seen object shall have this character. In one very striking series of experiments, for instance, outline perspective drawings of solid figures, regarded from an appropriate angle, take on an appearance of reality in the specific sense that they no longer present themselves as drawn upon a paper surface, but stand out in three-dimensional space. The lines which form them are 'liberated', so to speak, from their attachment to the surface, which is what normally causes them to appear as a two-dimensional drawing. By manipulation of conditions such as the microstructure and the relative contrast which affect such liberation, the degree of apparent reality can be effectively controlled. These and other experiments open up a field which should surely keep even Professor Michotte busy for many a year yet.

Taken all together, this work constitutes a massive, bold, and exciting exploratory attack on the perceptual mechanisms by which we become aware of and react to the external world in the way we do. It is a world of substances and things which, phenomenally at any rate, retain their permanence, their reality, their living or inanimate character, and which act causally on one another. Each of these aspects Michotte has brought under experimental study, and on every one he has shed light. But to me, at least, the inspiration to be derived from his work does not stem only from its results, but to a major extent from the quality of its manner. As to this, let me end with his own words:

[3] *Vide* e.g. A. MICHOTTE, *Bull. Acad. Roy. Belg.*, 1948, 34, 268–88, *ibid.*, 1960, 46, i–xv. A. MICHOTTE, *Arch. Psicol. Neurol. Psichiat.*, 1957, 18, 203–13. A. MICHOTTE, *Rev. int. filmol.*, 1948, 1, 249–61. M. R. PHEMISTER, *Quart. J. Exp. Psychol.*, 1951, 3, 1–18.

Preface to the English Edition

When the question arose of having *La Perception de la Causalité* translated into English, I found myself confronted with the same problem as occurred over the second French edition of 1954. Was it desirable to keep the 1946 text in its original form, or ought it to be re-drafted so as to take account both of new material discovered since the original date and of the way in which my own ideas had evolved? This would have necessitated an enormous amount of work and would have prevented me from devoting to other investigations which continue to arouse my enthusiasm such time as I might perhaps hope at my age to have at my disposal.

For this reason I decided, rightly or wrongly, not to modify the original text, but to add an extra chapter at the end (Appendix II), the main purpose of which was to state the theoretical issues which seemed to me of most importance. At the start (pp. 304–313) there is some detailed information about the methodological principles which I have followed in my research. Then comes the complete statement of the theory of perceived causality according to my present views, along with the arguments, based on a whole series of findings, for making changes which both simplify it and enlarge its scope (pp. 313–369).

No one is more aware than I am that this solution is only partially satisfactory, since it did not enable me to describe – let alone evaluate – a number of investigations which, although adding to our knowledge of perceived causality, did not have any direct relevance on the theoretical side.[1] In addition this procedure makes matters more difficult for the reader; and for this reason I should like to make a few suggestions to those interested which I think may make their task easier.

Before they read the main book it seems to me desirable that they should first read Appendix II, section 1 ('General Considerations on Method'). This will give them a better understanding of the precise scope of the work.

Secondly, it will be helpful for them to know at the outset that the

[1] On pp. 416–420 there is a complete list of all the research which, so far as I know, has been undertaken to date. Some of this material was published when my own book was already in the press, and in these cases it was therefore not possible to take the results into consideration.

Translators' Glossary

The meaning of most of Michotte's technical terms is clear from the context. In a few cases, however, particularly those where the French expressions have no straightforward English equivalent, readers may find it helpful to be given some further explanation. This is done in the glossary which follows. Page-numbers indicate where the word or phrase first occurs, and the original French expression is given in brackets.

AMPLIATION OF THE MOVEMENT: ('l'ampliation du mouvement') (p. 143). This refers to the extension of a movement from one object on to a second, in such a way that it remains the movement of the first object while bringing about the 'displacement' (change in position) of the second. For a discussion of the difference between 'movement' and 'displacement' see p. 134.

ENTRAINING, THE ENTRAINING EFFECT: ('entraînement, l'effet entraînement') (p. 21). This refers to the impression of one object joining another and carrying or pushing it along. Sir Frederic Bartlett has spoken of 'pushing with follow up'. Since 'entraînement' is used by Michotte as a technical term whose meaning is clear from the context, it seemed to us preferable to introduce the unfamilar word 'entraining' rather than try to find a more familiar word which would necessarily be somewhat misleading. The *Oxford English Dictionary* does in fact give a sense of 'entrain' fairly near the required one, viz. 'to draw away with . . . oneself'.

IMPACT-WHICH-LAUNCHES: ('choc-qui-lance') (p. 65). This phrase implies that the impact itself has the character of being active; it is the impact which actually *does* the launching. (For an explanation of the word 'launch' see below). Elsewhere the word 'choc' is translated either as 'impact', as in 'the impact-noise experiments' ('les expériences sur le choc-bruit') (pp. 235 seq.), or in some cases as 'blow'.

KINEMATIC: ('cinétique') (p. 4). A contrast is frequently made in the book between *static* Forms (Gestalten) and *kinematic* ones, i.e. those involving movement.

chief modifications introduced into my earlier theory are those which concern 'polarisation of the movements'. New observations have shown that, contrary to my original view, this phenomenon, interesting as it is in its own right, does not play the part in perceived causality which I formerly attributed to it. In addition, although the fundamentals of my theory have not changed, I have come to recognise that the factor of 'phenomenal permanence', to which there is allusion in several places in the original text, is in fact much more important for the theory than are the phenomena of polarisation, as will be seen in Appendix II, sections 2 and 3.

This being so, the theoretical views put forward in Chapter IV and in part of Chapter VIII (pp. 130–133) on polarisation of the movements have lost much of their interest as far as causality is concerned. The same does not of course hold of the experimental facts reported in these chapters, but they require to be reinterpreted. This is true in particular of the form taken by the 'radius of action' of the passive object as described and considered on pp. 53 seq.; the new account of this phenomenon is given on p. 338. With regard to the experiments on camouflaging the causal structures (pp. 72 seq.), these retain their demonstrative validity since they in fact relate to a point which is fundamental for the formulation both of the new theory and of the old (see the argument on pp. 346–347).

I cannot end without expressing sincere thanks to all those whose work has contributed to the publishing of the English translation of my book. First of all I am very grateful to Tim and Elaine Miles, who originally thought of the idea and who courageously undertook to translate a book full of nuances which could not easily be expressed in a language different from that of the author. They have done the job with remarkable competence and with a most commendable thoroughness. Next I must thank my old and close friend, R. C. Oldfield, who by using his distinguished reputation in support of the project enabled it to be carried through, and who kindly undertook to read over the English text before publication. Finally I must express my gratitude to Methuen and Co. for all the trouble which they have taken in connexion with both printing and editing.

Louvain, 1 October, 1962

A. MICHOTTE

TRIGGERING, THE TRIGGERING EFFECT: ('déclenchement, l'effet déclenchement') (p. 57). This refers to the impression that one object has 'touched off' the movement of another, the second object then appearing to move of its own accord.

All footnotes are Michotte's own except those which refer the reader to the glossary; these have been marked with an asterisk. Words and phrases to be found in the glossary are indicated as such only on the occasion when they are first used.

The translators would like to express particular gratitude to Professor R. C. Oldfield for reading the English text before its publication and for making a large number of helpful comments and suggestions. We are also very grateful to Professor Michotte himself for elucidating many points and for his co-operation and sympathetic encouragement.

T.R.M.

Bangor, 1960 E.M.

LAUNCHING, THE LAUNCHING EFFECT: ('lancement, l'effet lancement') (pp. 20–21). This refers to the impression of one object 'bumping into' another and setting it in motion. The French word 'lancer' has regularly been translated as 'launch'.

LAUNCHING-IN-FLIGHT: ('lancement au vol') (p. 66). This refers to the impression which occurs when two objects are in motion and when the first comes up and sets the second in motion yet again.

PHENOMENALISM: ('phénomenisme') (p. 13). The word is used in this book in connexion with the views of Piaget on the child's awareness of causal links. According to Piaget, causal links can be established for the child between any two separate events even in the absence of any rational knowledge connecting them. Thus if a child says that a pebble sinks 'because it is white', the causal relationship would be of this 'phenomenalist' character.[1] At an early age, however, the child in forming his conception of causality also takes account of his own feelings of effort or 'efficacy'. Hence arises Piaget's view that the child's awareness of causal relations involves both 'phenomenalism' and 'efficacy'. (Compare p. 13 of this book.)

PHENOMENOLOGICAL: ('phénomenologique') (Appendix II, p.304). Phenomenology in Michotte's sense is the study of the way in which things appear to the subjects in perception, as indicated by their verbal descriptions.

PRIMARY FACT: ('fait primitif') (p. 11). The French phrase is taken from Maine de Biran, and refers to the basic impression of effort, which he claims to be the source of all ideas of cause and force.

TRACE-MAKING, THE TRACE-MAKING EFFECT: ('traçage, l'effet traçage') (Appendix I, p. 289). This refers to the making of a trail, stain, or mark by an object. Either the object appears to *cause* the trace ('traçage causal', *Causal Trace Effect*), or the trace appears to *emanate* from the object ('traçage-écoulement', *Emanation Trace Effect*, p. 297).

[1] For further discussion see J. Piaget, *The Child's Conception of Causality* (tr. Marjorie Gabain), Kegan Paul, London, 1930, especially p. 253. In the present work we have decided in favour of 'phenomenalism' as a translation of 'phénomenisme' in preference to Gabain's 'phenomenism', since 'phenomenalism', as used in British philosophy, has at least some of the required associations. The translation 'phenomenalism' is also that adopted by Margaret Cook in *The Child's Construction of Reality*, Kegan Paul, London, 1955.

Contents

Introduction

Mechanical Causality

PART ONE—THE LAUNCHING EFFECT

Author's Note

The results of the research described in this book seem difficult to reconcile with the many different theories put forward by psychologists and philosophers as to the origin of the idea of causality and its application to the data of experience. For this reason I have been at pains to ensure that the conclusions reached should have as sound and broad a basis as possible. The experiments on which these conclusions depend have therefore had to be very numerous.

In order to follow the general development of our ideas, however, and to understand the theoretical views which we have been led to adopt with regard to the perception of causality, it is not necessary to be familiar with all these experiments. It should be possible, without any disadvantage, to omit certain chapters which are particularly full of technical details, and to read instead the series of 'summaries' in which I have given a résumé of their contents. This has been done mainly for the benefit of those who are not very familiar with laboratory work in psychology, but who are nevertheless interested in the problem with which this book is concerned.

One final point. Since I wished throughout to insist on the purely experimental character of the work, I have deliberately avoided all discussion of the philosophical significance of our results, reserving this question for a later study. I have limited myself to a brief statement of my position in relation to the classic views of Hume and Maine de Biran, which are, of course, the starting-point for present-day philosophical thinking on the subject of causality; and my discussion has dealt only with the question whether these theories find confirmation or justification in the experimental data.

Commentary

(by T. R. Miles)

References

INTRODUCTION

CHAPTER I

The Problem

I. HISTORICAL SURVEY

At a conference held during the Ninth International Congress of Psychology at Yale, U.S.A., in 1929, and in some lectures given at the Collège de France in 1937, I ventured to suggest that laboratory research on human perception should concern itself more than it had done in the past with *action*. Among the numerous problems which arise in this connexion, I mentioned in particular that of the perception of mechanical actions – the actions exerted by one body on another. It is this problem which forms the principal subject-matter of the present work.

Since then I have undertaken extensive experimental research on the subject. Some of the results, and a number of theoretical conclusions to which the research led, have already been published as a preliminary work. This was written in a non-technical style, and was intended for readers of a philosophical journal.[1] The present work contains not only the technical details which are of interest to specialists in psychology, but also descriptions of many new experiments, and an account of such developments in the theory as we have been able to make as a result.

As has often been said before, perception is simply one phase of the total process of action, and its biological rôle is to initiate and direct the behaviour of men and animals. It not only provides material for their contemplation, but invites them to action, and allows them to adjust this action to the world in which they live.

The phenomenal world does not consist of a simple juxtaposition of 'detached pieces', but of a group of things which act upon each other and in relation to each other. Thus the regulation of conduct requires a knowledge *of what things do* or *can do* and what living creatures (and ourselves in particular) can do with them.

We need to know that things can be moved, e.g. by pushing them, causing them to slide, lifting them, or turning them over, by hurling, breaking, bending or folding them, by leaning on them, and so on. We

[1] A. MICHOTTE, La causalité physique est-elle une donnée phénoménale? *Tijdschrift voor Philosophie*, III, 2, 1941, 290–328.

walls for?', and when I explained, he replied, 'Then pictures *aren't anything*!' This is a good illustration of the extent to which, for us, the essence of things consists in what they are able to do.

Among the functional relations which give things their significance, the causal relations which unite them clearly play a very considerable part. These, however, are not the only ones that have to be considered. Spatial relations can fill this rôle, for instance. Thus a child will for a long time think of a hat as an object 'which one puts on one's head', and a box as an object 'inside which one puts other things' without thinking of their functions of protection and conservation.

All this seems so obvious that nobody, with the exception perhaps of some extreme behaviourists, would wish to dispute it. Moreover, it is only necessary to read the works of psychologists who describe and study behaviour to realise the major part played by functional relations, whatever theoretical views these psychologists hold about them.[3] The study of these relations, however, has found only a very small place in the work of psychologists of the experimental school. The only problems which have to any extent aroused discussion concerning relations are (i) the theoretical problem of the knowledge of relations in general, and (ii) a more empirical problem, that of the origin of functional relations. According to the prevalent view, these were considered to be the product of a secondary elaboration of what is given by the senses. The result of this was to give them a significance which by themselves they did not possess, but which was in some way superimposed on them.

On this account of the matter it is clear that the question of functional relations has to pass to a second level in the psychology of perception, or at any rate must be reserved for further study, the fundamental problem on this view, the experimental problem *par excellence*, being that concerned with what is actually given.

The revolution brought about in the problems of perception by the new approach of the Gestalt psychologists was of a kind to raise the question of functional relations in quite a different way. In spite of this, the research done up to now by the representatives of this school has scarcely touched the problem. This is understandable, since the first task confronting them was obviously that of re-examining and recasting

[3] The wealth of material makes references almost superfluous; but among the most distinguished works on this subject recently published in French may be mentioned those of P. JANET, particularly *Les débuts de l'intelligence*, Paris, 1935, and *L'intelligence avant le langage*, Flammarion, Paris, 1936, and the numerous writings of Piaget on child psychology.

need to know, too, that certain gestures, certain looks, or certain words can attract or repel other men and animals, or modify their conduct in some other way.

Similarly, it is necessary to understand the influence that things exert on people – hurting us when they bump into us, pricking or cutting us, resisting our efforts, confronting us with shapes that are easy or difficult to handle, and so on.

Again, we need to know that one object goes up to another or withdraws from it, that one person pursues another or hides from him, that people lock up objects in drawers or chests, pour wine into glasses, and so on.

These examples are taken from situations which occur regularly in everyday life, and they are so ordinary that they do not seem at first sight to raise any special problems.

This, however, is not the case. Although these events all have a spatial and a kinematic* aspect, the most important feature about them is that they imply *functional relations* between objects. These relations are largely outside the range of the many investigations that have been carried out on the subject of space-perception and perception of movement. Even in a case as simple as that of our last example, do we not see the wine *come out* of the bottle and *run into* the glass? That is something quite different from a simple change of position in space.

These functional relations, then, constitute the essential fabric of the phenomenal world; they must be considered as a highly important factor in the adaptation of activities to their environment. They are important, also, in enabling an external observer to understand the human and animal conduct which he sees, and in this connexion they play a major part in social psychology.[2] It is these relations which give the things around us their significance, since it is by coming to know what things *do* that we learn what they *are*. What they are for us is much more than their shape, their size, and their colour; it is above all what they are capable of doing, or what can be done by means of them.

Here is a story which illustrates this point. One of my children, when aged about three or four, once asked me, 'What are pictures hung on

* *Cinétique*. See Glossary.

[2] Some writers have particularly stressed the part played by functional relations in animal psychology, e.g. W. KÖHLER in *The Mentality of Apes* (tr. E. Winter), Kegan Paul, London, 1927 (also in Pelican Books), and E. C. TOLMAN, both elsewhere and especially in his book *Purposive Behaviour in Animals and Men*, University of California Press, Berkeley, 1932.

us the idea of this determining and compelling action which is characteristic of what we call a power or force. They can touch only realised and known conditions, each separate from the other; the internal process uniting these conditions escapes them. Nothing that we learn could possibly suggest to us the idea of what an influence or efficaciousness is.'[5]

It is very interesting to contrast this quotation with similar passages from Hume. Indeed the Durkheim passage almost seems like a translation of Hume – a point which shows clearly the persistence with which the ideas of the British philosopher have been maintained.

By way of illustration, here are some characteristic sentences from the *Enquiry*.[6]

> 'It appears that, in single instances of the operation of bodies we never can, by our utmost scrutiny, discover anything but one event following another. . . . So that, upon the whole, there appears not, throughout all nature, any one instance of connexion, which is conceivable by us. All events seem entirely loose and separate. One event follows another; but we never can observe any tye between them. They seem *conjoined*, but never *connected*.'[7]

The idea of causality (in the sense of necessary connexion) is derived, as we know, according to Hume, from the regularity in the succession of phenomena; it is based entirely on anticipation, on the expectation that when one event occurs, another event, which ordinarily follows it, will do so again.

> 'After a repetition of similar instances, the mind is carried by habit, upon the appearance of one event, to expect its usual attendant, and

[5] E. DURKHEIM, *The Elementary Forms of the Religious Life* (tr. J. W. Swain), Allen and Unwin, London, 1915, pp. 363–4.

[6] D. HUME, *An Enquiry concerning Human Understanding*, section VII, part ii.

[7] It seems, to judge by a number of passages, that Malebranche had more perspicacity than Hume on this point, e.g.:

'When I see one ball bump into another, my eyes tell me, or seem to tell me, that this first ball is really the cause of the movement which it transmits to the other.'

'Nor does he [Aristotle] doubt that a ball which bumps into another ball has the power to set it in motion. This is how it appears visually and that is *sufficient for this philosopher; for he nearly always follows* the evidence of the senses, and rarely that of reason; whether this evidence is intelligible or not is a question which does not very much trouble him.' Quoted from L. BRUNSCHVICG, op. cit., pp. 6 and 7.

the information already obtained. As a result, the great majority of these works have been devoted to the perception of shape and movement as such.

In the present work I have limited myself to the question of the relation of causality; but it goes without saying that other functional relations can be studied along the same lines and by comparable methods. We have come across a number of these in the course of our experiments, and other research, now in process of being carried out, has been devoted to them.

Having defined the purpose of our work in this way, we must now examine the solutions which have been proposed or assumed by psychologists as to the origin of the idea of causality.

It is well known that the question of how this idea is acquired has had an important place in modern philosophy. This is not at all surprising in view of the extreme importance of the question in the natural sciences, in psychology, and in philosophy in general.

Now the problem with which philosophers such as Malebranche, Hume, and Kant were dealing was essentially an epistemological one. They were concerned to discover what could justify the characters of necessity and universality in causal relations, and the work of the empiricists was primarily intended to show that these characters could not be derived directly from the data of experience.[4] If matters had rested there, there would have been nothing in their views to cause us any special concern. But Hume has gone further. He has expressly asserted that in perceptual experience we have no direct impression of the influence exerted by one physical event on another. This assertion has been so widely accepted that it can still be regarded today as an almost universal assumption; and it is to be found in very different contexts. For example, the following lines come from the pen of one of our leading present-day thinkers, namely Durkheim:

'In the first place, it is evident and recognised by all that it [the notion of power] could not be furnished to us by external experience. Our senses only enable us to perceive phenomena which co-exist or which follow one another, but nothing perceived by them could give

[4] Thus, according to Malebranche, 'A true cause is a cause between which and its effect the mind perceives a necessary connexion.' Quoted from L. BRUNSCHVICG, *L'expérience humaine et la causalité physique*, Alcan, Paris, 1922, p. 7.

take the trouble to verify by systematic research whether Hume's claims were correct. It seemed definitely established that, from the point of view of perception, there were no other problems connected with physical causality except those of the distribution of objects in space and the perception of movement, change, succession, and simultaneity. Thus although writers for the most part did not even mention the question, we may assume that the very great majority of them would willingly have subscribed, as far as external experience is concerned, to this statement of Ziehen's:

> 'The idea of the relation of casuality is an empirical element that always appears when two successive ideas are very closely associated.'[8]

On the other hand, however, all psychologists were forced to take note of our natural conviction that we are the masters of our own actions, that we can produce at will the movements of our limbs, direct the course of our thought, etc., and, in short, that voluntary actions are initiated by the subject, i.e. by the 'self' which is their cause.

Hume, following Malebranche here, expressly mentions this belief and rejects it as fallacious:

> '. . . Our idea of power is not copied from any sentiment or consciousness of power within ourselves, when we give rise to animal motion, or apply our limbs to their proper use and office. That their motion follows the command of the will is a matter of common experience, like other natural events. But the power or energy by which this is effected, like that in other natural events, is unknown and inconceivable' (*Enquiry*, section VII, part i).

Hume admitted that the impression of effort against resistance can enter into the popular inaccurate idea of power or cause; but he denies that it has anything to do with power in the strict sense, which implies necessity.

> 'It must, however, be confessed, that the animal *nisus*, which we experience, though it can afford no accurate precise idea of power, enters very much into the vulgar, inaccurate idea, which is formed of it' (ibid., footnote).

[8] TH. ZIEHEN, *Introduction to Physiological Psychology* (tr. C. C. van Liew and Otto W. Beyer), London and New York, 2nd ed., 1895, p. 296.

to believe that it will exist. This connexion, therefore, which we *feel* in the mind, this customary transition of the imagination from one object to its usual attendant, is the sentiment or impression, from which we form the idea of power or necessary connexion' (ibid.).

Now, of course, it is not just the prestige of its author which has won for Hume's thesis the favour which it has found even with psychologists. From the evidence, the conclusion seemed inevitable that we never can, even by our 'utmost scrutiny', discover anything in the unfolding of natural events except their simple succession.

Indeed the truth of Hume's claim is obvious, so long as our observation of the facts is objective and analytical, as is the practice in the physical sciences. We are then trying to understand what is 'really' happening in 'the external world'; and, to do this, we examine separately the different parts of the object or the different stages of the event which we want to understand. That is what takes place, for example, when we try, like Hume, to understand what happens (in the physical world) when two billiard balls collide. Analytical observation clearly allows us to recognise only a succession of movements.

This type of observation has also been the one used by psychologists. As was only to be expected, after imposing itself on the natural sciences it spread to every discipline with scientific claims. As a result, nearly two centuries had to pass before it was realised that a wrong course was being followed, and that even though this mode of observation was the most suitable to give an accurate account of physical facts, it had the result of splitting the phenomenal world into pieces and making the most interesting psychological facts disappear. In the case which we are considering, it resulted in the suppression of the 'tye' of which Hume spoke, and whose presence Malebranche had so well recognised, as the quotation in note 7 shows. More details on this point will be found in Chapter VIII of this book.

Moreover Hume's view seemed all the more plausible since for a long time the world of sensation was regarded as a replica of the world of stimuli. As a result, it necessarily seemed impossible that anything should be perceived unless there was something corresponding to it in the sphere of stimulation. This ruled out the possibility of perceiving the 'influence' exerted by the impact of one billiard ball on the movement of another.

In view of this, it is scarcely surprising that psychologists did not

has, of course, in fairly recent times, found experimental confirmation in the work of Ach, Michotte and Prüm, and others.[10]

This opinion, in its extreme form, is found in the old and well-known theory developed by Maine de Biran. According to him, we have a direct experience of our own causality. This experience constituted, for Biran, the *primary fact** which provided the foundation for all psychology and all philosophy. It consisted

> 'in a simple fundamental relation that cannot be resolved in phenomenal terms, in which cause and effect, the subject and the act of performing, are indivisibly united in the same feeling or the same perception of effort (*nisus*). This effort has as its organ the muscles which obey the dictates of the will. It is from this original impression of effort that all ideas of force and cause derive.'[11]

Voluntary movement, then, is an act immediately experienced; it has as its culmination muscular sensations, and the self is its cause:

> 'It is in this change in the muscles surely, that effort shows itself internally. Effort is simply the soul's particular power in action. . . . Let us say, then . . . that the same internal feeling which reveals to the soul its own particular effort identical with this act of will, reveals at the same time the organic modifications produced by the effort, with its character of product or effect relative to its cause.'[12]

It is from this experience alone that the idea of causality is derived:

> 'A being who had never made an effort would not in fact have any idea of power, nor, as a result, any idea of efficient cause. He would see one movement succeed another, e.g. one billiard ball bump into another and push it along; but he would be unable to conceive, or apply to this sequence of movements, the idea of efficient cause or acting force, which we regard as necessary if the series is to begin and continue.'[13]

* *Fait primitif.* See Glossary.

[10] N. ACH, *Uber den Willensakt und das Temperament*, Quelle und Meyer, Leipzig, 1910, p. 240. A. MICHOTTE and E. PRÜM, Etude expérimentale sur le choix voluntaire, *Arch. de Psychol.*, X, 1910, p. 194.

[11] *Oeuvres choisies de Maine de Biran*, Editions Montaigne, Aubier, Paris, 1942, p. 165.

[12] Quoted from G. MADINIER, *Conscience et mouvement*, Alcan, Paris, 1938, pp. 169 seq.

[13] Quoted from L. BRUNSCHVICG, op. cit., p. 34.

'Internal' experience, then, is on the same footing as external experience, as far as causality is concerned.

This view of Hume's, to some extent made precise and amplified, has also been taken up by the associationist psychologists. While belief in the causality of the self is only an illusion according to these writers, there are none the less two phenomena which explain such a belief; the first is our ability to foresee a result before it actually takes place, the second the presence of a feeling of 'activity'. This theory has been brilliantly expounded in a classic work by Münsterberg.[9]

Starting from a radical sensationalism, he asks himself in what way sensations must be combined to produce the feeling of inner freedom, of active will.

One essential, he says, is a preliminary picturing to oneself of the result. In addition, however, we need to note the part played by organic sensations, and, in particular, what he calls the 'feeling of innervation'. (This is his term for the kinaesthetic memory of previous movements.)

> 'On all occasions, however, when we become conscious, during the act of will, of our own inner activity, there exists at that moment a lively feeling of innervation; it is precisely in this that the feeling of inner activity consists, and the strength of the exertion of the will is a direct expression of the intensity of the feeling of innervation' (p. 72).

Thirty years later the theme has scarcely changed, as is shown by the following passages, taken once more from Ziehen:

> 'We have yet to discuss the question as to how we come to regard the idea of our ego as the cause of our actions. . . . It is obvious(ly) . . . because of its very frequent appearance in the series of ideas preceding each action. It is almost always represented several times among the ideas preceding the final movement' (op. cit., p. 296).

In another passage he writes:

> 'This combination of motor sensations often gives our thought the character of attentiveness and an appearance of volition and self-activity which in fact do not belong to it at all' (ibid., p. 244).

Other psychologists, however, have continued to assert the existence in internal experience of a *specific* feeling of activity, characteristic of voluntary intervention and intimately linked with the self. This thesis

[9] H. MÜNSTERBERG, *Die Willenshandlung*, Freiburg, Mohr, 1888.

progressive objectification of causality' (*The Child's Construction of Reality*, 1955, p. 316).

Piaget's views are neatly expressed in the following formula:

'The idea of force . . . is the result of internal experience, but not of an experience which is felt as internal from the first' (*The Child's Conception of Causality*, 1930, p. 130).

To sum up, what is essential from our point of view is his assertion that the idea of causality in the child is linked with 'efficacy', i.e. with 'feeling a bond between the desire and the result obtained' (*De quelques formes primitives de causalité chez l'enfant*, 1925, p. 63).

This idea of causality involves a mixture of 'phenomenalism'* and 'efficacy'. In other words, the child is aware of particular events or phenomena (whatever they may be) between which links can be established, and is also aware of an 'efficacy' which gives these causal links their dynamic character. But in the case of the objective world, this early idea of causality fades and gradually disappears, to be replaced by the mechanical and rational conception of causality.[16]

Another view comparable with that of Biran is the sociological theory outlined by Durkheim.[17]

To Durkheim, no less than to Biran and Piaget, it is clear that the idea of causality cannot emerge from external experience, and that we must try to find its origin in internal experience. (See the quotation on pp. 6–7.) Nevertheless, he does not agree that Biran's theory provides the answer. This is because, in Durkheim's view, effort, or voluntary movement, is essentially a personal and incommunicable experience, and cannot therefore account for the impersonal and communicable character of power. On the other hand, the feeling of pressure exerted on the individual by the community satisfies all the conditions necessary to constitute a prototype of causal experience. This pressure does in fact come from outside (and is therefore impersonal);

* *Phénomenisme.* See Glossary.

16 Piaget's work, as everyone knows, has been outstandingly successful in giving rise to a considerable quantity of most interesting experimental research on the way in which causal explanations evolve during the mental development of the child. These studies, however, and the discussions resulting from them do not really provide material that can be used to solve the problems dealt with in this book which are of a different kind, and no special purpose would therefore be served in quoting them here. (For further discussion of Piaget's views see Chapter XVII.)

17 E. DURKHEIM, op. cit., pp. 365 seq.

phenomenal aspect of this link is *ill-defined*, or very variable, and there is no question of a characteristic impression of true causality, at any rate not one common to them all. These cases are no less interesting for that, and we shall have to return to them at the end of this book.

The thesis which I put forward at the Yale conference was in direct disagreement with all theories of the traditional kind which we have just been considering, since I expressed the opinion that certain physical events give an immediate causal impression, and that one can 'see' an object *act* on another object, *produce* in it certain changes, and *modify* it in one way or another.[20] I quoted various examples in this connexion, e.g. that of a hammer driving a nail into a plank, and that of a knife cutting a slice of bread. The question that arises is this: when we observe these operations, is our perception limited to the impression of two movements spatially and temporally co-ordinated, such as the advance of the knife and the cutting of the bread? Or rather do we directly perceive the action as such – do we see the knife actually cut the bread? The answer does not seem to me to admit of any doubt.

Since that time some progress has been made on this question, at least in the sense that a number of psychologists have made a close study of it.

Koffka expressly mentions, in his textbook of psychology, that on Gestalt principles it is perfectly conceivable that one should have a specific impression of causality.[21]

About the same time Duncker was led to consider the problem from a more specialised angle.[22] His research, it is true, did not bear directly on this point, but rather on the question of problem solving. But since solving problems frequently involved the discovery and use of causal relations, the author was compelled to try to give some account of the relevant psychological ideas.

Duncker rightly emphasises that, where there are causal relations, the

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[21] K. KOFFKA, *Principles of Gestalt Psychology*, Harcourt Brace & Co., New York, 1935, pp. 378 seq.

[22] K. DUNCKER, On Problem Solving (tr. L. S. Lees), *Psychol. Monog.*, 1945, 58, no. 5.

yet, on the other hand, it makes itself felt in our inner life. It intervenes in the form of a constraint; individuals say that they 'feel' it 'when it is acting upon their wills, to inhibit certain movements or command others'.

Admittedly we have here only the beginnings of a theory, as Durkheim himself says; and it may be doubted, too, whether it really bears upon the problem of causality. Indeed, it appears to be concerned with motivation rather than with causality; and it seems as if the imperative character of community influence is perhaps better fitted to explain the idea of obligation or duty than the ideas of necessity and production.

Quite apart from the question of voluntary action, the world of internal experience presents us with other data which are interesting in connexion with the problem of causality. They are summed up in the statement, made time and time again by writers concerned with introspective psychology, that emotions, needs, and tendencies are directly linked with the events which give rise to them, or with other events which result from them. Here there is not just a simple succession of independent phenomena, but an intrinsic bond which observers, rightly or wrongly, often describe in terms suggesting a causal connexion.[18]

In the interesting chapter which he devotes to 'insight' in his *Gestalt Psychology*, Köhler devotes many pages to stressing this point, and cites an impressive set of examples indicating links of this sort.[19]

These examples are extremely instructive. Indeed we can appreciate how difficult it is to determine, or rather to indicate in a satisfactory way, the character of the link in cases of this kind. I had myself made a similar observation in the course of Phelan's experiments, in which I took part as a subject (and that is my reason for referring to this work rather than to that of others). Köhler too, in the course of his exposition, makes use, no doubt intentionally, of a great variety of expressions; he uses the general term *direct determination* to refer comprehensively to a whole series of nuances. We have the impression e.g. that this *depends on*, *arises out of*, *follows from* that, that we do this *because of* that, that this *develops from*, is *based upon*, is *related to*, *springs from*, *refers to*, *is the outcome of* that, we see *the how* and *the why*, etc.

The wealth of such expressions clearly shows that, even if there is no doubt as to the existence of a link which we 'directly experience', the

[18] See, for example, in this connexion, G. PHELAN, *Feeling Experience and its Modalities*, Uystpruyst, Louvain, 1925, pp. 249 seq.

[19] W. KÖHLER, *Gestalt Psychology*, Liveright, New York, 1947, pp. 349 seq.

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two events, effect and cause, are not always so 'detached' or separate from each other as Hume had indicated. In many cases there is a certain degree of 'Einsichtlichkeit' – the quality of being accessible to insight; in other words, the link between the two is at least partially open to view.

First, this link can be seen in the spatial coincidence of the two events; the spatial position of the cause is shown by the spatial position of the effect. Thus when the problem involves bringing into a cage a banana which is outside, as in the classic experiments of Köhler on apes, the location of the banana indicates the point in space where the cause must intervene; the position of the cause is not just *any* position, but is marked by the position of the effect.

Secondly, the link is to be seen in the temporal coincidence of cause and effect. Thus, according to Duncker, when a gust of wind blows a door shut, and at the same time an electric light happens to go on at the other end of a corridor, the impression of a causal relation is forced upon us, so decisive is the factor of temporal coincidence.

Thirdly, the link can be seen in the direct correspondence often found between effect and cause, both as regards form and matter. When one billiard ball strikes another, it conveys to it a movement which, by and large, is analogous to its own and in the same direction. The tracks left by an object, e.g. the marks made by the paws of an animal, have the same shape as the object which imprints them; the humidity of the rain passes into the humidity of the pavements which it wets, and the same holds in other cases. In short, the characteristic shape, appearance, direction, etc., often pass from cause to effect in a way that can be immediately intuited. *Causa aequat effectum.* If that has been neglected by Hume and his supporters, it is because they chiefly had in mind cases where this correspondence does not exist – cases of simple releasing, or cases in which movement from cause to effect is concealed. The coincidences and correspondences which we have just been considering cannot always be immediately intuited, but when they can the search for causes is made very much easier.

In fact, according to Duncker, the chief point is this:

> 'We generally perceive as "cause" of an event, of a singularity, another singularity which coincides spatially and above all temporarily with the first. This in its turn results as "intersection" of two uniform developments or "world-lines".' (Weltlinien) – i.e. lines extending in space and time (p. 67).

It is essential, then, to the 'cause' event that it consists of an 'encounter'; thus the coming on of an electric light coincides with the encounter of two world-lines, that of the switch and that of the arm in motion, and appears to be effect of the two of them; and in the same way, the wetting of the pavement coincides with the encounter between the rain and the path.

Metzger has devoted a page of his recent psychology book – a work of profound scholarship – to the question of phenomenal causality.[23] He too is convinced that one can have an immediate impression of causality in external experience, and he stresses the importance of the structural principle of proximity in space and time for producing this impression. He adopts a general formula similar to that of Duncker:

> 'Thus there are two breaks in the general continuity. The one, the cause, is the coming together of two entities previously separate and unconnected; the other, the effect, is the genesis or passing away of some entity, or a change in it as regards any quality, state, or mode of behaviour.'

He particularly stresses the point that phenomenal causality implies the passage from one object to another of a process or a property of one of them; and he has above all the merit of expressing this idea in very precise terms.

> 'Qualities of the cause reappear in the effect; in other words, at bottom, nothing new comes into existence; rather there is simply the transfer of something already existing to a new bearer. . . . In the most obvious case, the colliding of two billiard balls, the two entities which come together merely exchange certain qualities. . . . This happens in such a way that, while there is *discontinuity* as regards the individuality of the two entities, the 'world-lines' of their respective qualities or states, as they transfer from one bearer to the other, remain continuous.'

These assertions seem extremely bold; for even if daily experience often allows us to recognise a similarity between effect and cause, the *transfer*, the *leap* of one and the same property from one object to the other is surely not visible. Indeed, if it were, we should have difficulty in understanding how Hume's thesis came to be so popular.

Yet, as will be seen later, the ideas expressed in this last quotation from Metzger have some affinities with the theory which has emerged

[23] W. METZGER, *Psychologie*, Steinkopff, Leipzig, 1941, pp. 120 seq.

as the result of my own research, at least in the sphere of mechanical causality.

2. CAUSALITY AND ACTIVITY

So much for the historical background to our problem. The next task is to give an account of our own research.

The first requirement was obviously to try to produce experimentally some typical causal impressions, and to determine by tests the conditions in which they occur. As might be expected, we began by examining the classic case of one object striking another. From our very first trials we were able to establish a fact which is important both theoretically and from the point of view of practical experimentation, viz. that the causal impression was not necessarily dependent on the use of 'real', solid objects. It can be produced perfectly clearly by using objects which are simple coloured shapes without apparent thickness, or even images projected on a screen; and this is possible even when the observers know perfectly well what is going on. Our task was thus greatly simplified, and it became possible for us to carry out experiments of many different sorts. We were able to vary in a systematic way such things as the colour, size, and shape of the objects, the speed and direction of their movements, the amplitude of their paths, the temporal interval between the 'action' and the 'reaction', and so on.

Next we contrived to make the causal impression appear and disappear at will; and we were able to compare directly the cases where it occurs with those where it was absent. The study of these cases, as we shall find later, brings to light the operation of laws closely related to the Gestalt laws. It is thus possible to link causal impressions with other perceptual phenomena that are already known. We can also exclude categorically any attempt aimed at reducing this impression to a 'projection' of our own power into things, or alternatively to a secondary 'interpretation' based on past experience and acquired knowledge.

When we had disposed of these problems we were confronted with a second task, that of 'understanding' the phenomenon, of making a theory about it, of seeking to find out why such and such conditions were necessary for its production, and why it possessed such and such properties. This constituted a counter-proof, such as would provide a definite demonstration of the original and primary character of the causal impression.

The method which we systematically used for this purpose was that of *genetic analysis*. This consisted essentially in simplifying in various

ways the conditions which had been found necessary for producing the causal impression, and in comparing the resultant impressions with those given by the original complete experiment. We could then see in what respects the two were different and in what respects they were similar, and were thus able, step by step, to trace the genesis of the causal impression. Moreover we could determine which among the many stimulus-conditions accounted for the presence of a character (that of productivity) which, considered in isolation, seemed at first sight to belong exclusively to the causal impression.

Briefly, the aim of this analysis was to reveal the genealogy of the causal impression, and if possible to re-discover by this means traces of more simple phenomena. These traces are so much modified in the causal impression that at first glance they may sometimes pass unrecognised.

The use of this kind of analysis in the psychology of perception is reminiscent of the method employed in all comparative sciences, e.g. comparative anatomy. Just as the latter succeeds in discovering the 'significance' of rudimentary organs, and in connecting them with fully developed organs, by following the different stages of their evolution, so in the sphere of perception it is possible to follow the evolution of phenomena, and to recognise similarities of structure beneath the apparently very different forms which they may take. Just as this procedure enables us to 'understand' a rudimentary organ, and to resolve the problem which it presents, so it will be possible by the same means to 'understand' the characteristics of the causal impression. There is no need to call attention to the full implications of this method; its usefulness will be seen in the actual course of the exposition.

Although we had this twofold purpose, the experimental research did not itself fall into two distinct parts. The experiments for determining the conditions in which the causal impression appeared were usually also those which were helpful from the point of view of genetic analysis.

Our work is based on two fundamental experiments. Here is an account of them:

Exp. 1.[24] The observer sits at a distance of 1·50 metres from a screen, in which is cut a slit 150 mm. long and 5 mm. high. Immediately be-

[24] For ease of reference throughout the book, every experiment described has been given a number. As a result, even in the case of experiments differing only in details which seem unimportant at first sight, different numbers have been used.

hind this screen is a uniform white background, on which stand out two squares of side 5 mm. One, a red square, is in the centre of the slit; the other, a black square, is 40 mm. to the left of the first. We shall call the black square 'object A', and the red square 'object B'. The subject fixates object B. At a given moment object A sets off and moves towards B at a speed of about 30 cm. per sec. It stops at the moment when it comes into contact with B, while the latter then starts and moves away from A, either at the same speed or, preferably, at an appreciably lower one, e.g. 6 or 10 cm. per sec. Then it stops, after covering a distance of 2 cm. or more, according to the speed adopted.

A large number of the experiments quoted in this book will be described as modifications of the above. Unless there is an indication to the contrary, the speeds may be assumed to be equal.

The speeds mentioned in the various experiments are those which were actually used. They are not the only possible ones, however; and, except in the case of very slow movements, a divergence of a few cm. per sec. has little effect on the results obtained.

The result of this experiment is perfectly clear; the observers see object A bump into object B, and *send it off* (or '*launch*' it),* *shove it forward, set it in motion, give it a push.* The impression is clear; it is the blow given by A which *makes B go*, which *produces* B's movement.

This experiment and the following one have been tried out on a large number of subjects (several hundreds) of all ages. All of them have given similar descriptions, with the exception of one or two, who, observing in an extremely analytical way, said that they saw two successive movements, simply co-ordinated in time. Moreover the same experiment has been tried hundreds of times on some subjects, and their impression of causality remained unaffected.[25]

* *Lancer*. See Glossary.

[25] It sometimes happens, however, that the causal impression does not appear at the first presentation of the experiment, especially when it is tried on 'new' subjects who are not accustomed to observing in the artificial conditions of the laboratory. Yet such subjects do not instead receive the impression of a clear co-ordination of two movements; they are all 'mixed up' and do not realise what is going on at all, and their impression is chaotic and unorganised. Provided that the experiment is repeated a few times, however, a structuring in favour of causality will arise spontaneously.

This time-lag in perceptual organisation has no theoretical importance, for it clearly is due to the particular conditions of the experiment, its unusual nature, and especially perhaps to the small dimensions of the objects. (The latter has a great influence on structural organisation in cases of imperfect fixation, as will be seen later in Chapter III, exp. 7.) This time-lag can be eliminated completely by producing the experiment in a different way, e.g. by the projection method (cf. Chapter II), which allows us to use objects of considerable size. In these conditions the causal impression is forced upon us at the very start.

Exp. 2. The conditions are the same as for the preceding experiment. The only difference consists in the fact that object A, after reaching object B, continues its course without changing its speed. From the time when they come into contact, object B in its turn starts to move off at the same speed as object A. The two objects remain side by side during their common movement and form by their combination a bi-coloured rectangle, which covers a distance of 3 or 4 cm. before stopping.

Here we have the impression that object A *carries* object B *along* (or 'entrains' it)*; that it *takes it with it*, that it *speeds it up in passing*, or again, if the speed and size of the objects are varied, that it *pushes it ahead*. The impression of causality is again clear; it is A which *makes B go forward*, which *produces* the change in B's position.

These are the two Type-experiments of causality; we shall call them respectively the *Launching Effect* and the *Entraining Effect*†.[26]

In the case of these two experiments the production of movement is thus *directly experienced*. There is no question of an interpretation, nor of a 'significance' superimposed on the impression of movement; in other words, what is actually 'given' is not a mere representation or a symbol of causality. In the same way as stroboscopic movement is not, psychologically speaking, the 'symbol' of a movement, but *is* a phenomenal movement, so the causality perceived here *is* a phenomenal causality.

Now obviously a movement seen at the cinema can 'represent' the movement of a so-called 'real' object; but it is a movement which represents another movement in the same way as a shape drawn on a canvas can represent the shape of a 'real' object. Similarly, the causality sometimes perceived on the cinema screen may represent the causality exercised by one 'real' object on another 'real' object; but from a psychological point of view it is still one phenomenal causality representing another.

* *Entraîner*. See Glossary.

† *L'effet lancement, l'effet entraînement*. See Glossary.

[26] The term 'effect' is, of course, used by physicists to indicate certain particular occurrences, such as the 'Thomson Effect', etc. I shall be using it in the same sense. To guard against any possible misunderstanding we might say, using current psychological terms, that it indicates a phenomenal 'given', which exists *sui generis*. Thus I shall speak of the 'Withdrawal Effect', so as to distinguish the specific impression of 'withdrawal' from the impression of simple movement which can quite well correspond to a withdrawal actually taking place in the visual field but where the objects are not seen in relationship to each other. (See Chapter IV, 2.)

A slight modification of expts. 1 and 2 brings out particularly clearly the specific character of causality as we experience it. Let us suppose that we introduce an interval of a fifth of a second or more between the two phases of the experiment (i.e. between the time when object A joins object B, and the time when object B begins to move, whether or not it is accompanied by A), and let us then make a direct comparison between the two impressions received, first when there was an interval, and secondly when there was not.

The presence of the interval makes the causal impression disappear completely. A is seen to approach B, hit it, and stop beside it in such a way that they form one block, a bi-coloured rectangle. Then a new scene is presented independent of the preceding one; in exp. 1 B separates from A and moves away from it, and in exp. 2 the bi-coloured block simply begins to move as a block, as a 'whole'.

The result of this comparison is striking, and all observers agree in asserting that the impressions are radically different. In the one case we find two events intrinsically linked, with the first of them 'producing' the second, and, in the other case, two events that are obviously separate, which arise successively, and which on their own give no impression of causality.

This last point needs to be emphasised, since, in theory, the two phases taken separately could quite well correspond to different causal influences. The approach of A towards B could give the impression that A is attracted by B; its stopping at the moment of contact could give the impression that B is an obstacle which prevents the movement of A from continuing; and the separation at the second stage could give the impression that B is repulsed by A, etc. Now in fact nothing like this happens. Not only is there no causal impression, but there is no tendency towards a causal 'interpretation' in these cases.

On the other hand, the isolated phases do not instead constitute simple experiences of movement, of change of position. They present the remarkable characters of 'approach' and 'withdrawal' which we shall be studying later; and they also present a special character which we must call attention to at once, that of an undeniable *activity*.

This demands some explanation. The term 'activity' is often used in books on psychology, but unfortunately in a rather different sense. It is therefore essential to make clear what is meant by it. In my use of this term there is no suggestion of a 'liveliness' of movement, nor of an impression of agitation, nor of an impression of tension and excitement

in the sense that has become familiar from Wundt's theory. When I speak of activity in connexion with the experiments which we have discussed, I mean to indicate that we see the object *act*, we see it *do something*. This is very different from the perception of a simple change of position, and even the most naïve observers frequently and unhesitatingly make a distinction between the two.

It is, of course, difficult to fix the lower limits of this impression, and one could discuss indefinitely the legitimacy of the application of the term 'activity' to movement as such. This question, however, is irrelevant and of no special interest; for the essential facts are that observers spontaneously differentiate between the two cases, and that in addition activity is found to have differences in degree which are extremely marked. Whether there is, at the lower limit, a simple difference of degree or a qualitative difference is of minor importance.

In the present group of experiments and with the speeds which we have used – this is important – the impression is given that A 'goes towards' B, that it *strikes it*, that it *hits it*, and that it unites with it, and again that B leaves A, that it *withdraws from it*, and sometimes that it *runs away* from it.[27]

In other cases, in particular when B stays still and A after reaching B returns to its starting-point, a different impression is given. If certain speed conditions are satisfied, it appears that A *strikes* B, or, when the movement recurs at fixed intervals, that A *hammers* or *pounds* B, and this constitutes a much more marked activity.

In the launching and entraining experiments the character of activity is still more marked; and it finally reaches its maximum in the case of live movements, such as creeping or swimming. We have produced these movements in a schematic form under controlled conditions, and the effect is astonishing.

Activity, then, is a phenomenal character *sui generis*. This is very interesting, since even if 'internal' observation does not allow us to come to a definite conclusion on these points, it is obviously quite a different matter when there are 'external' observations; in the latter

[27] In order to avoid all misunderstanding, it should be pointed out that the impression of activity is obviously linked with the perception of wholes. The moving and non-moving objects have to be integrated in one and the same 'whole'. This is, in fact, how we do see things if we observe naïvely. An 'analytical' approach, on the other hand, which results in the isolation of the moving object, necessarily causes the character of activity to disappear, and substitutes an impression of simple movement.

case the experimental conditions can be modified in a systematic way, and can be repeated as many times as we please.

The question is also important from our special point of view, since activity and causality have often been confused by psychologists. To quote a particular example, it is this error which seems to be at the basis of Biran's theory, as we shall see at the end of this book. There are in fact two distinct 'experiences', and these correspond on the perceptual plane to different stimulus-conditions. The conditions which give rise to the impression of activity are simpler than those of causality, and we come across them more often. Indeed they are produced each time there is an impression of causality. That is why all cases of causality are also cases of activity, while the converse is not true.

This distinction gives rise to certain difficulties which it is necessary to remove. It might seem that if one has the impression that an object is 'doing something', causality must necessarily be involved. Such a view has something to recommend it, since even in the cases which I have quoted, and purely from the phenomenal point of view, it might justifiably be said that there is both a cause and an effect distinct from one another.

Thus in the impact example it seems quite clear that the coming into contact of these objects is an event distinct from the movement which brought them together, and results from it. Must we not, therefore, consider the movement of A towards B as the cause of the impact? Yet observers refuse to admit that in the case of the movement of A and its impact with B they have an impression of causality comparable in any way with that which the Launching Effect provides; and when they are asked whether there is a cause and an effect at that stage, and which is the cause and which the effect, they seem at a loss. The movement of A does not *produce* the impact in the same sense as the impact produces the eventual movement of B.

The key to the enigma is given by the following considerations. It is true that by an analytical and abstract approach such as I have adopted above, it is possible, theoretically, to distinguish two successive events, the movement and the contact. But actually there are not *two events*; there is only one event which develops progressively. As we shall see later, the impact is not really limited to the coming into contact of the two objects; it constitutes a whole *process*, of which the movement and the contact are both constitutive parts. This process evolves. It begins with an approach which links the two objects from the

start, and results in a union which becomes gradually closer. At its final stage, it ends in a complete fusion or welding together.[28] There is perhaps at this moment a rather abrupt qualitative change; but, in any case, this coming together is simply the limit, the ultimate phase of the progressive changes which lead to it. The whole is *one* gradual development.[29]

When observers say, for example, that A gives a 'bash' to B, they certainly do not mean by this that it is the movement of A which gives the bash to B, for the word 'bash' clearly includes the movement. Nor again do they mean that object A is itself the cause of the bash, which would amount to saying that it is the cause of its own movement. They simply mean, as one can easily see on reflexion, that object A executes the *operation of striking*.[30]

This action is peculiar to object A, and constitutes A's condition at that moment; A is the *sole executant* of the action. As far as object B is concerned, it takes no effective part in the process, and its rôle is limited to serving as a point of reference for object A. Thus the operation is closed and complete; it demands no consequence, and moreover it has none. As will be seen later, when we develop the theory of the causal impression in Chapters VIII, IX, and XIV, no consequence could possibly arise in these conditions; for if this is to happen, object B has to participate in the process as executant of one phase of the action.

This discussion of the distinction between phenomenal causality and activity was necessary in order to delimit the scope of this book. We shall not be concerned to any great extent with the question of activity, which has still to be studied, and which will be discussed on its own in a separate publication.

As far as causality is concerned, there are two major sets of problems, those connected with *mechanical causality*, and those connected with *qualitative causality*. These will be considered successively; and after

[28] See Chapter IV, 2.

[29] The unity of the process is perhaps even more obvious in the opposite case, that of the separation of the objects; for it is clear that although their dissociation is distinct from the subsequent movement, it cannot possibly be considered as the cause of the latter, but only as the form taken by it in its first stages.

[30] The phrase 'give a bash' ('donner un coup') is ambiguous. It can imply, as in the present case, the exercise of an activity; but it can also denote a case of causality, as when the word 'bash' is used to indicate a dent or other damage brought about by a blow. In this case a distinction can be clearly drawn between cause and effect.

they have been examined, we shall give some consideration to the question of *the origin of the idea of causality.*

Readers may perhaps be surprised to find that there is such a great difference in the amount of space devoted to each of the two major questions; for at first sight it seems that qualitative causality must be at least as important as mechanical causality. This disproportion, however, is justified by the very nature of the results of the research, which have been positive in the first case and negative in the second.

As far as mechanical causality is concerned, the two Type-cases already mentioned, the Launching Effect and the Entraining Effect, will be studied successively in detail. The problems raised by the Entraining Effect are the simpler of the two, and it would perhaps have been preferable on logical grounds to deal with entraining first. But the very difficulty of the question of launching has led us to concentrate our efforts on its solution, and it is on this subject that we have made the largest number of experiments – experiments, moreover, which form the basis for an explanation of entraining. It is for purposes of convenience, then, that this order of presentation has been adopted.

Before describing the experiments, I shall give a detailed description of the experimental apparatus by means of which they were carried out.

CHAPTER II

The Experimental Apparatus

The research whose purpose has just been described required special apparatus, the construction of which gave rise to a number of difficulties. It would be easy of course to invent a device which gave the impression that two objects were colliding, or pushing one another, even when they were really moving independently; and it would be quite possible to control their movements as required. An arrangement of this sort is described in the course of this book (see Chapter V). This method, however, has its limitations, because of the effect of inertia, and does not lend itself well to a sufficiently large range of experimental variations. For this reason, having discovered that the use of solid objects was not at all indispensable for the success of the experiments, we decided to use purely optical methods. These were very much more adaptable and easy to control.

It would have been perfectly suitable, as far as our research was concerned, to use a film of animated drawings projected at a rate of 64 per second (which is quite feasible); they would then appear at intervals of no more than 16 milliseconds, which would have been perfectly adequate for our requirements.

Unfortunately an enormous amount of work is involved in making the films, and the expense is more than any ordinary laboratory could stand. We therefore decided at the outset to abandon this method.[1]

I. THE DISC METHOD

This method is based on the well-known illusion of movement produced when a strip of paper with a slanting line drawn on it is moved vertically behind a horizontal slit cut in a screen. In such circumstances, as is well known, we see an object or coloured spot travelling sideways from one end of the slit to the other. The slit must not be too wide, and it must not be possible to see the vertical movement of the paper; for this reason there should be no grain on the paper and it must be moved fairly rapidly.

By this procedure it is possible, by the use of different combinations

[1] It should be noted, however, that this method, reduced to the form of stroboscopic experiments, can give results of great value for the solution of some of our problems, as will be seen later.

of lines drawn on the moving paper, to make several objects appear in the slit, to vary the distances between them and the times at which they appear, and to give them whatever speed is required. This is the general principle on which our experiments were based. We applied it systematically, using the very convenient method of revolving discs. This method was as follows: on each disc is drawn the arc of a circle, having at its centre the axis of the disc, and the disc is rotated behind a fixed screen in which a narrow slit has been cut along the line of a radius. As a result, each time the arc goes past a motionless spot is seen behind the slit. If this arc is replaced by a curve constructed in such a way that it gradually approaches the centre of the disc, the spot will be seen to move towards the centre or towards the periphery, according to the direction in which the disc is rotated.

The *time* during which the spot is motionless, or appears to move, is determined by the angle at the centre subtended by the curve and also by the angular velocity of the disc, according to the formula:

$$t = \frac{\theta \times T}{360}$$

where θ is the size of the angle in degrees and T is the time in seconds for a complete rotation of the disc.

The *length of the path* of the apparent movement, (L), is determined by the angle at the centre subtended by the curve and by what I shall call the 'slope' of the curve (S), i.e. the distance, expressed in cm. per degree, over which it approaches the centre.[2] The length of the path, in cm., can then be expressed as follows:

$$L = \theta \times S$$

The *linear velocity* of the apparent movement depends on the amount of slope and the angular velocity of the disc. Thus

$$v = \frac{S \times 360}{T},$$

v being the velocity in cm. per second.[3]

[1] To produce these patterns, it is only necessary in practice to determine every 10 degrees the points where the curve intersects the radii of the circle, and then to draw the corresponding curve with a template or 'French curve'. This can very easily be done even in the case of a slope of 0·01 cm. per degree. (The smallest slope that we used was 0·005 cm. per degree, and in that case the points of intersection were determined every 20 degrees.)

[2] In most of our experiments we used an angular velocity of 1 to 1½ seconds per rotation. With a slope of 0·11 cm. per degree, this gives linear velocities of about 40 to 25 cm. per second. A speed of 40 cm. per second can be considered fast, in view of the small size of the objects.

All this, of course, applies only when the movement is uniform, this being the only case considered in our experiments. But it is obvious that the method lends itself quite as well to the production of accelerated movements.

Here, as an example, is a combination of discs which was used at the beginning of our research. It should be noted, however, that the launching experiment which results from this combination is not performed in the most favourable conditions, since the two objects are moving at the same speed. If one of the movements is considerably slower than the other a better result is obtained; but I have chosen this combination of discs for purposes of illustration because the diagram brings out more clearly the special shape of the two curves and is more helpful for the understanding of the text than is an example in which the two speeds are different.

The first disc (Fig. 1, A) is made of very stiff paper; its usual size is 50 cm. in diameter. On it is drawn an arc 0·5 cm. thick, 1 cm. from the outside edge, and coloured black. This covers an angle of 70°. It is continued as a curve with a slope of 0·11 cm. per degree (strictly speaking, 0·1125) for the next 40°; this causes the thick black line to move 4·5 cm. towards the centre. The curve is then continued for 130° by another arc the radius of whose inner edge is 19 cm. All this makes up object A in exp. 1, p. 19.

A second disc (Fig. 1, B), of radius 19 cm., has on its periphery an arc also of 0·5 cm. thick covering an angle of 130°, in this case coloured red. The arc, like that on the first disc, becomes a curve, with a slope of 0·11 cm. per degree, for 40°, after which there is a final arc for 70°. This is object B in exp. 1.

The two discs are put one on top of the other, and set up behind a screen in which a horizontal slit has been cut along a radius. The slit is 15 cm. long and 0·5 cm. wide (Fig. 1, C).

If the discs are set up as indicated in the diagram, an observer will see a small red square of side 0·5 cm. in the centre of the slit, and a similar black square 4·5 cm. to the left of the red one. If the combination of discs is then turned slowly in an anti-clockwise direction, object A will shortly begin to move, and will go and take up position beside object B. For a while the two objects will remain together without mov-

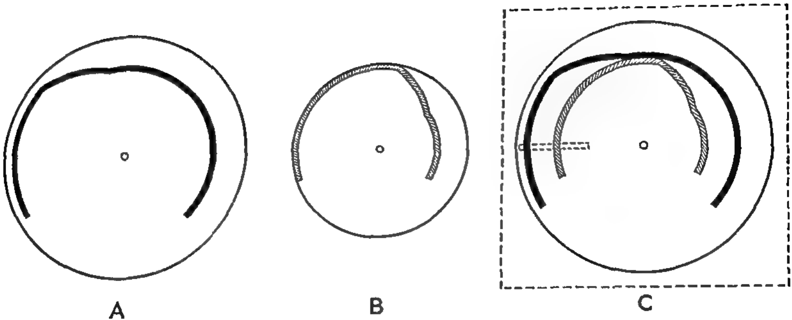

FIG. 1. Combination of discs for use in experiments on launching. Scale 1 : 10.

ing, and then object B will move away from object A and stop when it has travelled a distance of 4·5 cm.

The relative timing of the movements of the two objects is of course determined by the relative position of the discs. When B's slope directly continues that of A, the second movement succeeds the first without interruption. When, however, one curve is shifted through a number of degrees (as in Fig. 1, C), an interval is introduced which is expressed by the formula:

$$t' = \frac{\theta' \times T}{360}$$

where θ' is the number of degrees through which the disc is shifted and T is the time in seconds for a complete rotation of the disc (or milliseconds if that is the unit used to measure the intervals, as is actually more convenient).

The above example will readily serve to indicate the way in which the discs were constructed for the experiments described later in this book.

Let us now consider the observation conditions. First of all, it is often necessary (and always useful) to arrange the apparatus in such a way that the subjects do not see the disc. This can be achieved if the screen in which the slit is cut is made sufficiently large, or more simply if the subjects are made to do their observations through a tube (say, 3 cm. in diameter and 30 cm. long) through which they can see only the slit and the part of the screen immediately round it.

All the observations described in this book, unless there is any indication to the contrary, were made at a distance of 1·50 m.

The point of fixation is of some importance, as will be seen later; this is chiefly because of the smallness of the objects when the disc method is used. Our usual practice was therefore to ask our subjects to fixate the *point of impact*, which in most cases was determined by the starting position of the object which is struck. In the other cases the point of fixation was indicated by a faint mark made at the required place at the edge of the slit. Again the results are just as good if the observer fixates the motor object and follows its movement as far as the point of impact. The essential condition for the success of the experiments is that at the time of impact the area in which this impact takes place should be clearly seen.

I should mention at this point that we used the same method in a simplified form for a small pocket-sized apparatus on which it is possible,

after a little practice, to make a number of very interesting observations. This instrument is particularly useful since with it the experimenter takes only a few minutes to try out and determine the effect of combinations which he intends to produce on the discs.

The apparatus consists of a metal sheet 90 mm. high and 76 mm. wide, in the centre of which is cut a horizontal slit with a bevelled edge; the slit is 50 mm. long and 0·5 mm. wide. The back of the sheet is fitted with a groove (made by folding back the edge of the slit) along which the operator moves by hand simple slips of thin cardboard 75 mm. wide and 125 mm. long, like those used for a card index. On these are drawn in pencil the lines to be used for giving the illusion of movement.

The disc method has proved extremely valuable for our research. With it a very large number of combinations of movements of one or more objects can be produced at little expense. The movements can be in any direction – horizontal, vertical or oblique, according to the position of the slit – and can take place in conditions in which the speed, the length of the movement, the distance between the objects, and the time interval can all be measured.[4]

Moreover the movements produced are, of course, independent of the laws of inertia, and it is therefore possible to produce effects that contradict the laws of mechanics and are at variance with what we have

[4] The disc apparatus lends itself to an amazing variety of applications. This is because it is possible to put several other discs on top of the two main ones. If slits are cut in the top discs, it is possible to make additions to the patterns on the discs behind, or screen them off. Alternatively one can cut the discs along a radius and overlap one disc on another. We have done this from time to time; and it is thus possible to lengthen particular lines at will, and by varying the length of the corresponding arc to change the time-interval during which one of the objects is motionless. It is also useful to fit the slit in the screen with grooves, and then to slide into them a strip of paper to form a tunnel through which the objects move, or a special frame for part of the slit, or fixed objects, or shutters to limit the visible part of the path.

I should also point out that some of the experiments mentioned in this book can be produced by stroboscopic means, and the discs can be used for this too. All that is necessary is to indicate the objects in their first and final positions by means of concentric arcs with different radii, and shift the arcs at an angle to each other according to the time-intervals required. This, however, is a curiosity rather than a practical method of experiment, since stroboscopic movements are too abrupt and too little adaptable to systematic graduation of speed to be of any use in solving most of the problems with which we were faced.

learned from experience. This is clearly a point of considerable importance in some connexions.

Nevertheless the disc method has certain limitations. First, only rectangular objects can be used, and virtually the only direction in which their size can be varied is along the length of the slit, since the height of the slit has to be very small if the illusion of linear movement is to be fully effective.

Secondly, it is difficult with this apparatus to produce movements other than rectilinear ones, or to change their direction en route; nor is it possible to produce movements whose paths, though converging at a particular point, come from different directions. Yet this is sometimes necessary for the purposes of our research (see Chapter VI, 2). This result can be obtained only by altering the shape of the slit and the design of the disc both at once; even then there are limits to what can be done in this direction.

Thirdly, the moving objects are passing along behind a slit which makes a 'corridor' for them. From the point of view of perceptual organisation, this produces special conditions which are clearly favourable to the unity of the whole.

Lastly, the shape of the object is not absolutely the same when it is at rest and when it is moving. Although a simple arc drawn on the disc does give an almost perfect image of a square in the slit, because the arc has a large radius, the same does not hold of the curves moving towards or away from the centre. These are necessarily at an angle, and give an image of diamond shape which is more marked the greater the slope. (The largest slope which we used was 0·11 cm. per degree.) The result is that at the moment when the object begins to move and also at the moment when it finally stops, slight changes of shape take place. These are not perceptible when the speed of rotation is high and the slope is small; but they are clearly seen when the speed is very slow and the slope greater.

One final point should be mentioned. The disc method, as we have just described it, necessitates the experiment being repeated at intervals that are determined by the speed of rotation. This can and indeed does have a certain influence on the perceptual structure. Consequently we ought to consider to what extent the results obtained differ from those which would have been given by a single presentation. It would of course have been possible to introduce an extra device that would limit the performance to one turn of the disc; but as far as we were concerned

there was no special point in this, since our second method enabled us to achieve the same end more simply, and also eliminated all the shortcomings of the discs.

I should point out that, so far, the results obtained by this second method have at every point confirmed those obtained by the first; in particular they have shown that the change in shape of the objects and the fact that the experiments repeat themselves are of no practical importance for the problems which we were studying.

2. THE PROJECTION METHOD

This method consists in projecting images on to a screen by means of two Kodak 2 × 2 in. miniature projectors. The projectors are set up in such a way that they can each be rotated through several degrees, thus producing a linear displacement of the images on the screen.

Our problem was to discover a mechanical system by means of which we could vary as we pleased (i) the positions where the objects began and ended their movements, (ii) the times when these movements were released, and (iii) the relative speeds and directions of the movements.

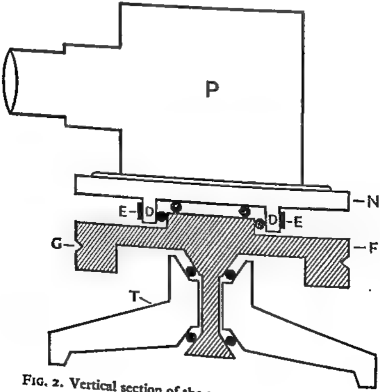

FIG. 2. Vertical section of the apparatus. Scale 1 : 3.

For this purpose we constructed a special stand for each projector. The following is a brief description of it.

The tripod T (Fig. 2) supports a heavy cast fly-wheel F turning on its axis. This is the driving part of the apparatus; it is controlled by a driving-belt which engages in the groove G.

The projector P is set up on a table N, which is attached to the fly-wheel on which it is resting by ball-bearings set in its base D.

In addition, there is a brake-band by means of which it is possible to control the tightness of the coupling between the table and the fly-wheel. This strap is the essential link between the two parts of the apparatus. It consists of a flexible steel band E binding the base of D of the table which is also fastened at both ends to the fly-wheel. One of the ends is fitted with a spring, whose tension can be varied, and by means of which the frictional force can be modified as required (Fig. 3).

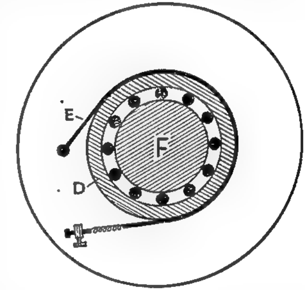

FIG. 3. Horizontal section of the apparatus in the plane E-E

It is easy to see how the apparatus works. When the table is blocked in any way the projector is stopped, but the fly-wheel continues to move. Conversely, when the table is freed again, it is carried round by the strap fastened to it, and the projector travels at the same speed as the fly-wheel until it is stopped again. Thus it is possible to cause the image to move across the screen at a given speed between two given positions.

This is all very simple in theory. In practice, however, several requirements have to be satisfied, and they necessitate certain precautions.

1. Since the result is dependent upon the speed of the fly-wheel, this must be perfectly uniform. The decrease and increase of load which occur when the projector is freed and stopped respectively must not be allowed to influence the speed of the fly-wheel, i.e. the variations in the load must be negligible in relation to the driving force and the permanent load. This result was obtained by the use of a sufficiently power-

ful motor ($\frac{1}{2}$ H.P.), by the addition of an extra brake-strap running on the rim of the fly-wheel and by the reduction of the excess load (see below). For full effectiveness, belts should be used that will not stretch, e.g. having a cross-section of trapezoid shape. As things were, we were unable to obtain these at the time and had to be content with round belts made of leather, which had certain disadvantages. These belts were in fact not completely free of extensibility. Consequently the image sometimes jumped a little at the start and did not take up normal speed until the projector had been rotated through about one degree. There was a similar defect when the object stopped. It should be mentioned, however, that these defects were perceptible only when the speed was high; they were scarcely noticeable at speeds of 20 to 25 seconds per rotation, which were those generally used. Moreover they could be eliminated completely if the apparatus was set up with extra care.

2. The starting of the projector needs to be almost instantaneous. In other words, the strap, when it is free, must not slip on the table which must be carried round immediately at the speed of the fly-wheel. In the same way there must be no recoil when the table stops. This means, of course, that the strap must exert sufficient force to overcome the inertia of the table and projector together; thus both of these must be made of very light materials in order to make the mass as small as possible, and the rotation must be very slow.

As will be clear from what has been said, the brake-strap mechanism must conform to contradictory requirements. On the one hand, the force which it exerts must be as small as possible in order to reduce the excess load and not upset the evenness of the movement; on the other hand, it has to be fairly large to overcome the inertia. Consequently great care is needed in adjusting the strap.

Let us now consider the apparatus used to start and stop the two projectors. We have to remember that one projector (that used for producing object B in our experiments) must be started by the other (that used for producing object A) at some point during the latter's course, and that it must be possible to limit the extent of these movements as desired. This was arranged as follows:

Projector A: The table carrying the projecter is fitted with a long arm, made of a light metal (Fig. 4, A), at the end of which is a toothed segment S, whose teeth are cut so that each corresponds to an angle of half a degree. This gives the image projected a possible movement of 21 cm.

when the projector is one metre away from the screen, and 42 cm. when it is two metres away, and so on. It should be noted that where the angles are as small as this, no appreciable error is involved in considering the extent of movements of the images as directly proportional to the angle.

Opposite the toothed segment is a peg (P), used to block the segment at some point on the scale, and a stop controlled by a screw to bring it to a halt at the end of its course.

To set the apparatus going, the operator moves the table until the peg engages in the required tooth of the segment, and this fixes the starting-point. When the peg is withdrawn, the image begins to move, and stops when the arm reaches the stop L. In this way the image travels a fixed distance. Its starting-point can be varied, but it will always stop at the same place.

If we want to alter the stopping-place we can do it in one of two ways: either the slide in the projector can be moved horizontally, or the projector can be swung round on its supporting table. The second way is useful if the path of the object has to be shifted to any large extent. It is inadvisable to change the position of the stop L, since that involves regulating the peg afresh, and also the contact, which I shall describe in a moment.

Projector B: The starting-point is determined by an electro-magnet attracting an armature, Ar (Fig. 4, B), which is fastened to the table supporting the projector. When the current is switched off, the table moves as far as the stop L. (The position of this can be changed without any trouble so as to limit the extent of the movement.)

The time when B departs, relative to A, is thus controlled electrically. A break switch C (Fig. 4, A), which responds very easily, opens the circuit when struck by a knob T on the segment S attached to projector A. This switch is fixed on a sliding bar that can be moved by means of a micrometer screw controlled by the crank-handle M. By this means the circuit of the electro-magnet can be opened at some moment during the course of segment B.

If the electro-magnet were connected directly with the switch C, it would be possible to start B either at the moment when A stops (as in the launching experiments) or while it is moving (as in the entraining experiments), but it would not be possible to introduce a time-lag between the stopping of A and the departure of B, as is necessary for some investigations. For this reason we inserted a relay R between the switch and the battery, which gives a fixed time-lag of 150 milliseconds. It

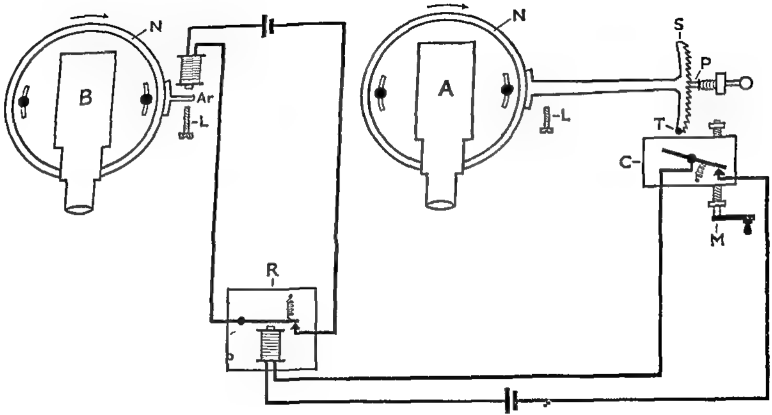

FIG. 4. System for releasing the movements of the two projectors.

is then possible to vary the position of switch C so as to obtain any time-lag up to the maximum of 150 milliseconds, which is sufficient in practice.

The movements of the projectors were under the control of a single motor, operating by means of a transmission system, which allowed for different combinations of speeds in the following ratios for the two projectors: 5:1, 3:1, 1:1, 1:3, and 1:5.

As regards the objects themselves, we chiefly used shapes cut out with a knife or punched out from small strips of thick black paper. On these, when necessary, we stuck pieces of coloured gelatine.[5]

The experimental conditions obtained by this apparatus are obviously less crude than those obtained by the disc method. They also open up fresh possibilities, viz.

1. Objects of any shape and size can be used.

2. The speeds can be altered very considerably and the projected image enlarged to correspond.

3. The images can be moved on a background that has in practice no limitations: the light can be either bright or dim, and they can be set in a frame of determinate size and shape.

4. The relative direction of the paths can be altered either by moving the slides up or down in the projectors (for a parallel shift) or by using a set of mirrors (for an angular shift). (See Chapter VI.)

5. The two objects can be made to move in different planes (ibid.).

6. By adding simple devices, it is possible to co-ordinate the movement of an object with a purely intensive or qualitative change in another object (see Chapter XV).

I should mention also that the same apparatus can obviously be used for any kind of research in which movement of objects is involved. For instance, it has been extensively used for some recent work on phenomenal permanence.[6]

On the other hand, many experiments which can be performed by the disc method cannot be performed by the projection method. This is true, for instance, of experiments in which the movement of one object

[5] The equipment which I have just described and the discs which we used were constructed with remarkable precision and accuracy by our technical assistant, L. Roland. I should like to take this opportunity of thanking him very warmly, and of paying tribute to his skill and inexhaustible patience.

[6] A. C. SAMPAIO, *La translation des objets comme facteur de leur permanence phénoménale*, W[illegible] Louvain, 1943.

changes speed on the way, and also of those in which more than two objects are performing movements simultaneously.

Consequently we have found it desirable to use both methods. In practice we more often used the disc method, and reserved the projection method for control purposes and also for experiments which could not be performed in any other way.

I should like at this point to thank all those who acted as subjects in our experiments. The permanent staff of the laboratory, consisting of Professors Montpellier, Nuttin, and Michotte, as well as the assistants, took part in all of them. Some experiments, which required a large number of subjects, were also tried out on students. Others again – and these were of course the most important ones – have been repeated with very many observers (several hundreds) either during lectures given to groups of university colleagues, or in practical demonstration classes.

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MECHANICAL CAUSALITY

Part One: The Launching Effect[1]

The experiments described in the Introduction have shown that it was possible to create the appearance of a distinctive causal impression. Our problem now is to determine the necessary conditions for this impression, and to use the method of genetic analysis in examining its distinctive character.

In the Type-experiments we were concerned with two objects which each performed a movement. The experimental conditions can thus be varied either with regard to the objects or with regard to their movements. I shall examine each of these two possibilities in turn, the first in Chapters III to V (for a résumé see Summary No. 1), and the second in Chapters VI and VII (for a résumé see Summary No. 2). I should point out, however, that this is a very artificial distinction, since the part played by the objects can of course be viewed only as a function of the movements that they perform; thus the two aspects of the problem to some extent overlap.

By this procedure we shall have assembled the elements necessary for the understanding of the Launching Effect as a composite whole. In Chapter VIII I shall study this composite aspect, and try to formulate the theory underlying it.

[1] The Launching Effect can be produced in different ways, either by one object striking another as in exp. 1 (launching-by-striking), or by one object flinging out another (launching-by-expulsion). I shall here be concerned only with the former. It differs from entraining more than does launching-by-expulsion; consequently a study of it provides particularly valuable information. The case of launching-by-expulsion will be examined in Chapter X.

CHAPTER III

The Segregative Influence of the Objects

If someone not familiar with the problems of perception were asked to say what part is played by the objects in a case of launching, his reply would be very simple – the presence of two objects is required because one of them has to give the blow and the other has to receive it. From a psychological point of view, however, such a reply would be inadequate, since what we want to know here is not how the launching of an object is brought about, but rather what is needed to *give the impression* of launching; and this is quite a different matter. As a result it will be necessary to ask questions which from a physical point of view may seem senseless. Our first question is a case in point.

The Type-experiment of launching has shown that it is possible to receive the impression that one movement (that of object A) has produced another movement (that of object B). What is involved is thus a link, of a special kind, *between two movements*; and it follows that we are justified in asking ourselves whether it would be possible to produce a causal impression in the case of two successive movements of one and the same object in such a way that the second movement seems to arise out of the first. To answer this question we performed the following experiment:

Exp. 3. The experimental conditions of exp. 1, p. 19, are modified as follows: object B is suppressed; object A starts off, stops at the usual place, and then moves off again at the same speed, or at a different speed, for a distance of several centimetres. The halt-time can be regulated as required.

The result is always the same. In these conditions no observer ever received a causal impression. When the halt is very short the movement seems continuous, even when the speed changes considerably (see expts. 44 and 45, Chapter VII, 3). When the halt-time increases, the movement is still unbroken, but the object seems to be held up at some point on the way, as if it had 'caught' on something. When the halt is longer still there is a different impression, that of 'a movement of the object in two stages', but subjectively without a halt. Thus there is still a very strong unity of the whole, although there is a clear distinction

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and return movements; in particular it is very clear when the combinations are 40 and 8 cm. per sec. respectively, and still more so when they are 75 and 15 cm. per sec.

By contrast, if the two speeds are slowed down, the character of action is noticeably weakened and the *movement* character becomes dominant. For example, when there is a combination of speeds of 15 and 3 cm. per sec. respectively, we receive the impression that object A goes up to B, touches it, and then departs again.

The introduction of an interval at the point of impact, between the outward journey of the object and its return, produces a similar result so long as this interval is of appreciable duration, say 50 to 100 milliseconds.

The experiments just described show that the causal impression requires two objects to perform the movements. Now the spatio-temporal requirements to which the movements are subject in the launching experiment often make it rather difficult to distinguish between the two objects, and this distinction can be maintained only if the stimulus-conditions are of a well-defined sort.

Above all, it is not enough that the two movements should in fact be performed by two objects of different appearance; it is also necessary that the two objects should be simultaneously present during each of the movements. This is shown by the following experiment.[4]

Exp. 5. This is the same as exp. 1 except that there is no period when the two objects are motionless at the point of impact. At the start object A alone is present; it sets off and goes to its usual stopping-place and immediately disappears. Then object B appears, already moving, beside the place where object A disappeared; it too goes to its usual stopping-place and comes to rest there.

Thus the two objects are present in turn in this experiment, and yet the impression given is that *there is only one, which does the whole journey* from A's starting-place to B's stopping-place; and this happens for the whole range of temporal intervals which can be introduced between the time of the disappearance of A and that of the appearance of B. This unification of the object occurs in spite of the difference in colour between the two objects (whenever this is noticed, which is not

[4] On the other hand, it is of little importance whether one of the objects is motionless while the other is moving as in exp. 1, or whether they are both moving as in expts. 17 and 19, Chapter IV, 4.

between the two sections of the movement. Finally, when the objective interruption is longer still, there is a phenomenal halt too, and the impression received is that of two distinct events.[2]

These slight differences are interesting; and we shall find similar ones in the case of the Launching Effect, which, as we shall see, is still perfectly clear in conditions corresponding to 'movement in two stages'. Thus it is clear that a distinction between *two separate pieces of movement* in spatio-temporal conditions similar to those of the Launching Effect is not a sufficient condition for the appearance of the causal impression.

This conclusion is confirmed by a study of the case in which an object *rebounds* against an obstacle. We might expect *a priori* that in these circumstances an impression of causality would be given, either between the first phase of the movement and the second, or between the object struck and the reversal of the direction of movement.

The experiment was conducted as follows:

Exp. 4. This is the same as exp. 1 except that object A, instead of coming to a stop after the impact, performs a return movement towards the point where it began. Object B does not move. The experiment was performed with different absolute and relative speeds; for the second movement (the 'return journey') we used various speeds including speeds $\frac{1}{5}$ to $\frac{1}{2}$ of that of the first (outward) movement, these being conditions particularly favourable to the causal impression in the case of the Launching Effect. Among the combinations used were those of 40 cm. per sec. for the outward movement and 8 cm. per sec. for the return journey; also the combinations 75 and 15, and 15 and 3 cm. per sec.

No trace of a causal influence was ever found in this experiment, any more than in exp. 3.

When there is no time interval between them, the two sections of the movement form a clear unity, but there is no impression that the return movement is caused by the outward movement, nor even that it is brought about by contact with an obstacle.

On the other hand, we should bear in mind that although there is no question of causality, a character of 'activity'[3] (i.e. the action of 'striking') is apparent here. This is the more pronounced when the speed is high, and to some extent depends also on the relative speeds of outward

[2] A table showing the exact times for these different stages is given in connexion with exp. 30, Chapter VI, 1, which is similar to the experiment quoted here.

[3] See Chapter I, 2.

joins it, and B sets off in its turn. A disappears at some stage during B's movement.

In these conditions, and *in the absence of any time interval* between the contact of the two objects and the departure of B, the impression gradually changes from one of continuous movement by one object, when the time of immobilisation at the point of impact is very short, to that of the Launching Effect, when the time during which the objects are both present at the centre is long enough for a distinction to be made between the objects. We have determined this interval for a speed of 35 cm. per sec., the times of the immobilisation of the two objects being equal; it was 100 milliseconds for subject Mi. and 130 milliseconds for subject Mo., i.e. approximately one-tenth of a second.[7]

I shall do no more than record this fact, since it is difficult to determine the reason for this minimum time in view of the fact that the objects play different parts in the experiment.

Thus distinguishing between the two objects implies distinguishing between the movements which they perform; *the objects act here as segregative agents for the movements.*

How and why does this happen? This is by no means as simple a question as one might think, and in order to answer it we must start our examination of the problem by considering the structural principles on which the perceptions are organised. The following experiments are very informative in this connexion.

When the launching experiment is carried out with objects of somewhat small size, as was done in the majority of cases, we discover what seems at first sight a very strange fact; we can pass with astonishing ease from the causal impression of launching to that of a continuous movement. All that is needed is to reduce in some way the sharpness of visual discrimination at the point of impact, as was done in the following experiment.

Exp. 7. Exp. 1 is performed in the usual way, and the subject is asked to fixate a point 7 or 8 cm. above or below the point of impact, so that he is looking at the point of impact indirectly. At the ordinary observation distance of 1·50 metres, the fovea covers an area of about

[7] We need here to take into account the duration of the 'rise of excitation', i.e. the length of time necessary before a person receives a clear image of the motionless object after it has become motionless. There is some evidence (see Chapter VI, 1) that this rise of excitation must in our experiments take about 30 milliseconds. The time of immobilisation in this present case is thus very much greater.

invariably), and in spite also of the fact that the disappearance of A and the appearance of B occur in different places.[5]

Otherwise the impressions are largely similar to those of exp. 3, and the same sequence is to be found, viz. uniform movement, movement during which the object becomes 'caught' on something, and movement in two stages. The intervals have to be longer, however, for the corresponding stages in this case than they do in the case where the object stopped, and a clear impression that there are two objects appears only with relatively large intervals of 200 milliseconds or more; only in such cases is there a clear break in the unity of the whole. The tendency towards unity is thus stronger in this experiment, where the phase of immobilisation at the centre has been completely suppressed.

The reason for this is obvious. It is the tendency towards unity in the movement which determines the apparent unity of the object, in spite of the differences in colour, etc.; and it is odd that the tendency towards unity of the whole should exert such a powerful influence in this direction that the unity of the object is maintained despite the fact that a differentiation is noticed in the two-stage period.[6]

On the other hand, segregation of the objects (and their movements) takes place as soon as the time during which they are simultaneously present is of a certain length. This length of time can easily be determined by the following experiment:

Exp. 6. This is the same as exp. 1, except that the time of immobilisation of the objects at the point of impact is limited. At the start only object A is visible. It sets off; but in the course of its movement object B suddenly appears, motionless, in the centre of the screen. Object A

[5] Complementary experiments show that it is likewise possible for differences in shape and size to be entirely ineffective. The impression given in cases where there is such a difference is that of an object changing its shape or size at a given moment on its course.

[6] We have also performed experiments in which the immobilisation phase was suppressed in the case of only one of the two objects. A disappeared at the moment when it reached B, which was present in the middle of the screen and began to move at the moment of contact. In these circumstances, out of a group of 41 subjects, 13 (32%) had an impression of launching.

When, on the other hand, B was absent from its point of departure, and appeared, already moving, beside A's stopping-place at the moment when A had just arrived there, 17 subjects (42%) had an impression of launching. See in this connexion Chapter X (Launching-by-expulsion).

The presence of the two objects during one of the two movements is therefore sufficient in a certain number of cases to produce the Launching Effect, but much less consistently than when the two objects are present simultaneously throughout.

Exp. 9. The same result is obtained again when the subject moves gradually farther away from the apparatus while still fixating the point of impact.

At a distance of six or seven metres, in the conditions of exp. 1, we once more find that the Launching Effect is replaced by the Tunnel Effect.

The influence of the size of the objects and their speed is clearly evident. We need only increase the dimensions of the moving objects or decrease the speed of their movement, and the Launching Effect reappears.

In this experiment the increase of the observation-distance has a double effect. First, it diminishes the size of the retinal images and thus to some extent the apparent size of the objects, and, secondly, it reduces the visual acuity (the Aubert-Foster phenomenon) as in the earlier experiments.

It is easy to show, however, that even where there is direct vision the actual size of the objects plays a part.

Exp. 10. This is the same as exp. 1 except that the objects are reduced to no more than a millimetre in width. The height is still 5 mm., the same as that of the slit.

At an observation distance of 1½ metres, the Tunnel Effect appears again. To receive a launching impression the subject has to approach the apparatus until he is only 30 or 40 cm. away from it, and even then the causal impression leaves much to be desired.

We may note in passing that all this seems largely independent of personal factors such as expectation, attention, and so on. It is no use in such experiments concentrating one's attention on the centre of the screen or on object A, or trying to give oneself the idea that there is an impact and a launching, since this does not in any way alter the impressions received.

What is the more remarkable about these experiments is that they set up combinations similar to that of the Type-experiment of launching, and yet the impression produced is quite different; it is similar in fact to that given by exp. 5, where the phases of immobilisation of the two objects at the centre were absent. Thus simple variations in visual acuity tend to cause these phases to lose their influence. This procedure enables us to decide what happens when the phase of immobilisation plays an influential part.

The great difference between the result of these experiments and the

3 cm. diameter, and the deviation of the line of vision in relation to the point of impact is about 3°.

In these conditions what the subject sees is *a single object, A, travelling the whole length of the slit in a continuous movement, and on its way passing over another object which is stationary at the centre.* There is no question here of either impact or launching.[8]

This phenomenon is in no way altered when observers notice the object change colour. It also appears at very different speeds; we have observed it even when the speed is 2 cm. per sec., although it seems that the slower the speed the farther away must be the fixation point to achieve unification of the movement. Conversely, this unification is less easily achieved when the objects are larger, and can hardly be achieved at all when the objects exceed a certain size.

As for the impression of one object passing over another, that is only a special case of a well-known phenomenon which it is easy to produce by hiding part of the course of an object behind a screen, or alternatively by showing two objects in turn at each end of a screen, thus producing a stroboscopic movement. This phenomenon is the Tunnel Effect.[9]

Exp. 8. The same result is obtained again with direct vision, if we put a small square of ground glass or a sheet of semi-transparent paper or a lens at a suitable distance between the eyes of the subject and the slit on the screen.

The images are very indistinct, and all that is seen is a shadow going along and passing over another motionless shadow at the centre of the screen.

[8] The object at the centre seems not only permanent and single, but even *motionless*; and oddly enough is seen to have only the colour of A. Thus there is no phenomenal trace of the change of objects. This seems rather odd when we consider that B disappears either at the same moment as A appears beside it, or after a negligible interval. One might expect this to give rise to a stroboscopic phenomenon of *retreat* from position B to position A. In fact this retreat is seen by some subjects, who apparently observe in a particularly analytical way. It is seen clearly by all subjects if we limit the field to its central part by hiding the outer part of the course of the moving objects. Moreover it is seen regularly when the experiments are produced by the stroboscopic method. The absence of the retreat in exp. 7 shows that something besides visual acuity is operating, and that certain structural factors must be interfering and thus suppressing the apparent displacement of the object at the centre.

[9] See especially in this connexion M. WERTHEIMER, *Experimentelle Studien über das Sehen von Bewegung. Drei Abhandlungen zur Gestalttheorie.* Verlag der philosophischen Akademie, Erlangen, 1925, p. 64.

phases of immobilisation at the centre (spatial and temporal continuity between the arrival of object A in motion and the appearance of object A motionless, between the disappearance of object B when motionless and the departure of object B in motion; tendency towards phenomenal permanence, and so on).

4. The tendency of the two movements to remain distinct because of the spatial interval separating them; this is equivalent to the distance between the centres of gravity of the two objects.
5. The tendency of the two phases of immobilisation to remain distinct because of the difference in their position and the fact that one occurs later than the other.

It was clearly factors 1 and 2 which influenced the four last experiments, while factors 3, 4, and 5 were dominant in the launching experiment.

Moreover we can understand this, since it is in this direction that the variations in visual acuity must operate. Thus it is well known that when the acuity is reduced the opposition between movement and rest generally acquires considerable importance in perception (particularly in the case of indirect vision). It is not surprising, therefore, that similarities of this sort are found to be among the most important forces of organisation. When vision is acute, on the other hand, the continuity is clearly seen between the phase of movement and the phase of immobilisation which precedes it or follows it, as also is the spatial discontinuity between the place where the first object stops and the place where the second object begins. Thus visual acuity favours, at one and the same time, the segregation of the objects and the unification of movements with the objects performing them.

It follows that if there is segregation of the movements in the Type-experiment of launching, this is because, in the last analysis, the conditions in which this experiment is produced guarantee that the two objects are distinguished, and favour the factors which link the movements with these objects. In other words, it is in virtue of the general laws of structural organisation that the objects exert the segregative influence which we have ascribed to them.

This conclusion fully confirms the statements which have been made by Ternus, von Schiller, Metzger, and others, following the lead of Wertheimer, that the same principles of organisation control both static and kinematic Forms.

Launching Effect clearly lies in the different type of perceptual organisation found in each.

In the case of perception of launching, the phase of movement that corresponds on the phenomenal plane to the physical movement of each object is linked with the phase of immobilisation belonging to the same object.

When, on the other hand, there is an impression of continuous movement by a single object which passes over a second object, the movements of the two objects and the phases of immobilisation at each end (that of A at its starting-place and that of B at its stopping-place) are linked on the phenomenal plane and seem to be the action of a single object. Similarly the phases of immobilisation in the centre seem to be that of a second object (the tunnel).

This phenomenon is exactly similar to that which occurs in the field of static forms, where cases are constantly found in which the impression is altered under the influence of a diminution in visual acuity. For example, if two squares are drawn side by side sufficiently close together and we look at them from some distance, we get the impression of a rectangle with a line cutting across it which has taken the place of the squares. This is a case exactly parallel to that in our experiments.

If that is so, however, it follows as a matter of course that the differences in structure observed in our experiments are derived from the combination of forces of organisation involved. The most important of these which can play an influential part at the point of impact are the following:

1. The tendency for the two phases of movement to unite (similarity of state, in that they are both moving; good continuation; similarity in appearance of the objects which perform the movements, and so on).
2. The tendency for the two phases of immobilisation at the centre to unite (similarity of state, in that both are at rest; similarity of shape; spatial contiguity; temporal contiguity between the disappearance of the one and the appearance of the other, and so on).

It is possible also to cite a number of factors acting the other way. Of these it is enough to mention the following:

3. The tendency of each phase of movement to unite with one of the

CHAPTER IV

The Polarising Influence of the Objects

1. THE RADIUS OF ACTION IN THE LAUNCHING EFFECT

If we look closely at what happens in exp. 1, it soon becomes apparent that the movements of the two objects have a different 'look' about them, even in cases where their speeds are equal. This is surely rather strange, since all the kinematic properties of these movements are identical, and the objects to which they belong are also alike. The only objective differences between the movements are external, viz. (i) that object A starts out from nothing, from empty space, whereas object B begins to move when A is beside it, and (ii) that object A moves towards B, whereas object B moves towards empty space. It therefore seems that these differences in some way affect the character of the two movements.

We also discover something else which is still more remarkable. Our first tests had of course been made simply by trial and error. We had decided quite arbitrarily the size of the objects used, their speed, and the length of their path. Now subjects remarked at times that B 'went farther than it should have done' or 'wasn't struck all that hard'; that after a certain distance it 'was moving of its own accord' and its movement 'no longer had anything to do with its having been struck'. Also they sometimes said of object A that it 'came from too far away' and that 'only a small part of its movement had anything to do with striking B'.

The actual Launching Effect seems to include only a part of the two movements on either side of the point of impact; I shall call this part the 'radius of action' of object A or object B.[1]

This phenomenon aroused our interest from the start. We were naturally inclined not only to consider it as a characteristic of the Launching Effect, but also to see here an example of something learned in the course of everyday experience. (This second assumption is in fact quite wrong, as our later research has shown.) At all events we tried quite early on to see if anything could be done about submitting it

[1] The term 'radius of action' is, of course, applicable only in the case of the object which is moving.

In concluding the discussion of this question I should like to emphasise that these first experiments point to the existence of very intimate links between the impression of launching and that of a continuous movement. This is a fact whose importance will become increasingly clear as the book proceeds.

function which cannot yet be defined with precision on the basis of the few numerical data collected so far.[3]

A second point is that for both subjects the radius of action of object B is in most cases smaller than that of A, but the difference is significant only in the case of subject El.

Finally, even in the absolute values, there is an approximate agreement between the two subjects, which in such a case is rather unexpected.

TABLE I

The Radius of Action for the Launching Effect

1. Subject Go.

Speeds:	32	16	11	8	5	4 cm. per. sec.
Radius of action of object A:	59·7	37·2	29·1	23·1	18·1	11·4 mm.
S.D.:	1·8	1·6	0·9	1·0	0 6	0·5 mm.
Radius of action of object B:	58·6	35·2	26·3	21·4	16·3	9 6 mm.
S.D.:	1·0	1·3	1·6	1·1	0 8	0·5 mm.

2. Subject El.

Speeds:	28·0	19·8	9·9 cm. per sec.
Radius of action of object A:	51·0	3·32	27·1 mm.
S.D. :	3·2	0·6	1·1 mm.
Radius of action of object B:	42·7	28·5	18·8 mm.
S.D.:	1·0	1·0	0·4 mm.

Subject Go. performed another series of experiments in which the two moving objects had different speeds. A moved at a constant speed of 40 cm. per sec. and kept a uniform course for 45 mm., whereas B moved more slowly. To obtain B's radius of action we took the mean of ten readings at each of the different speeds used. The following were the results:

Speeds of B:	32·4	18·0	10·8 cm. per sec.
Radius of action of object B:	67·4	50·7	25·3 mm.
S.D. :	1·7	1·0	1·3 mm.

[3] It should be mentioned at this point that the abundance of qualitative material which had to be collected for our research prevented us from fully developing its quantitative side. We limited ourselves to what was strictly necessary, and aimed especially at obtaining enough data to show the order of magnitude, as this seemed adequate for our purpose. Supplementary detailed figures will be added in later publications.

to measurement. We did this with some scepticism, for the small differences which we were trying to distinguish seemed so very nebulous and subjective. We soon discovered, however, that subjects who were conscientious and who were also good observers were quite capable of making these distinctions, and that the experiments regularly gave consistent results.

Exp. 11. This is the same as exp. 1, except for quite a simple change. Two movable shutters were fitted to the slit on the screen, thus making it possible to limit the visible length of the path of objects A and B as required. The maximum distance was 75 mm. for each object.[1] The task of the observers, who had all previously mentioned the existence of this phenomenon, was to limit the lengths of the paths by moving the shutters. They did so (i) until they obtained the impression that 'A was doing nothing else except push B forward', and (ii) until 'B seemed to have gone precisely the distance that it was pushed by A'. The method thus consisted in making adjustments. When the distance of movement was increased, on the other hand, the impression was given that 'A was travelling on its own account before pushing B' or that 'B was travelling on its own account after it had been pushed by A'. These expressions are quoted from the descriptions given quite spontaneously by the subjects.

The subjects who took part in these experiments went on to give ten readings of the radius of action for each object separately and for each speed used. Similar experiments were tried with other subjects, but we did not pursue them further, since the results were very similar to those of the first group.

The results obtained are recorded in Table I. This table shows in millimetres the mean and standard deviation of the radius of action both of object A and of object B. Figures are given for both subjects and for all the different speeds used.

For both subjects the size of the radius of action increases with the speed of the movement, and the differences are clearly significant, as is shown by the small amount of scatter. The relationship does not seem to be a simple proportional one, but depends on a rather complex

[1] By using shutters in this experiment we cut out the phases of immobilisation of the objects at the extreme ends. This does not in any way affect the impression of launching, and seems to be of little importance in connexion with the radius of action. We have been able to verify this in the course of experiments performed according to the method adopted in exp. 12. This method enables us to vary the distance of the movement and at the same time to retain the phases of immobilisation at the extreme ends; it involves the use of a set of discs, incorporating a complicated system of movable masks which we assembled a long time after we had concluded the experiments described here.

A'. This of course is only a metaphor, indicating in a very rough way the slight difference in the impression received. I call this impression the 'Relay Effect'. The Relay Effect is relatively unstable, and can fairly easily give place to an impression of mere contiguity, but it is of considerable interest from the theoretical point of view.[5]

Let us now consider the opposite case, that in which the distance travelled by the moving objects is reduced until it is less than the radius of action. To what extent is the Launching Effect now modified? It was in order to answer this question that the following experiment was set up.

Exp. 12. This is the same as exp. 1, except that object A travels different distances before reaching the point of impact. We used the following distances in mm.: 95, 75, 55, 35, 25, 10, and 5. The distance travelled by object B remained constant at 45 mm. The speed used was 30 cm. per sec.

We found that the Launching Effect still took place when the point of impact was fixated. At the observation-distance used, the length of 5 mm. corresponded to an angle of about 10 minutes, and the Launching Effect was almost as good as it is when the distances are greater. Thus it would not be far wrong to say that a causal impression must appear as soon as the threshold is passed beyond which a movement of A in the direction of B is clearly perceptible.

This depends on the speed used. Thus a distance of 5 mm. is more than sufficient for a relatively slow speed of 16 cm. per sec., and even for 30 cm. per sec. It is rather different, however, in the case of higher speeds, those of 40 cm. per sec. and more. In these conditions the movement of A looks more like a simple change, and the impression of launching gives way to that of 'triggering'.*[6]

[5] See W. METZGER, Beobachtungen über phänomenale Identitat, *Psychol. Forsch.*, XIX, 1934, p. 13. It is interesting to note that the word 'relay', which I used quite independently before reading this article, is very close in meaning to the term 'Postenablösung' ('passing on the baton'), which Metzger applies to a similar phenomenon. This is the best proof that the occurrence contains a genuine character of its own.

In Metzger's article there are also many very interesting observations on various combinations of movements which have likewise appeared in our own experiments, e.g. rebounding, passing of one object over the other, to-and-fro movement, and so on.

* *Déclenchement.* See Glossary.

[6] It is the first time that I have spoken of 'triggering' in this book. We shall meet many examples of it, and an accurate account will be needed of how it differs from launching. Later on, in Chapters VII and VIII, full details of these differences will be given. All that I shall say for the moment is that the

The influence of the speed is seen once more, but the absolute values differ from the previous ones. (The experiments were performed two days apart, and it is possible that the differences are merely accidental.)

The fundamental interest of these experiments will appear when we can compare the results with those obtained subsequently. For the time being it is enough to record the figures, and to stress that they give certain maximum spatial limits, and consequently temporal ones, to the action of the Launching Effect.

This action, from the phenomenal point of view, begins at the limit of the radius of action of A and ends at the limit of the radius of action of B. It can therefore be said that, in the conditions found in our experiments, *the launching action extended for a distance of about* 10 *cm. when the speed was* 30–35 *cm. per sec., about* 5 *cm. when the speed was* 8–10 *cm. per sec., and about* 2 *cm. when the speed was* 4 *cm. per sec. These values correspond in length of time to about a third of a second in the first case and about half a second in the last two.* This is the length of time taken by the action itself, or by what may be called, in a quite strict sense, the *period of transition.*

The parts of the movement which are outside these spatio-temporal limits have nothing to do with the launching action; they are just ordinary movements of no particular kind, and imply no relation between the objects. In some cases this can affect the causal impression of launching. Thus when the distances travelled, especially that of the motor object, are much longer than the radius of action, the impression of launching is greatly weakened and may even disappear, especially when the subject is not concentrating exclusively on the point of impact. In these circumstances the part of the movement corresponding to the radius of action is so small compared with the part of the movement which is seen in relation to the general framework that it is totally dominated by it. Thus object A seems to 'move on its own account' throughout its course, and its movement does not centre upon object B when it approaches it. The same is true of the movement of B, which then seems to be a mere repetition of the movement of A.[4]

In general, however, the impression obtained is not that of two totally independent events simply juxtaposed; rather it is an impression of a sort difficult to describe, viz. that 'B is carrying away something given to it by

[4] For successful results in this experiment the distance travelled should be made at least three or four times as long as the radius of action; the projection method is therefore preferable here to the disc method.

Exp. 14. This is the second part of exp. 1. Object A is in contact with object B; the latter sets off, covers a distance whose length has been extended to 8 or 10 cm., and then comes to a halt.

These experiments have been performed at a whole range of different speeds varying from 4 to 32 cm. per sec. The results are most immediately obvious, in the case of untrained observers, when the speed is limited to, say, 10 cm. per sec.

In these two experiments we find something similar to what has been described in the launching experiment. The movement changes character during its course. As long as the distance between the objects is fairly large, it looks in every respect like the movement which occurs in a uniform field; the second object plays no part, and is in fact no more than a mere 'accident' of the background. But it is quite a different matter when the distance between the objects is made sufficiently small. When this is so, in exp. 13 we see object A 'going towards' B or 'making for' B, and in exp. 14 we see B 'leaving' A, or 'going away', 'departing', 'withdrawing' from A. In these circumstances the second object is playing a part in the movement of the first object; it is in relation to the second object that the movement develops. In other words, in the course of the movement there is a change in its system of reference.[9] When the objects are a long way apart from each other, it is the screen and the slit in it which act as frame of reference for the movement, whereas, when the distance is less, the second object takes on this function and itself becomes *centre of reference* for the movement of the first object.[10] The particular appearance which it takes on in this case I shall call *polarisation* of the movement.

The centre of reference can be either in front of or behind the moving object in relation to the direction of its movement. Thus we have to distinguish two kinds of polarisation – direct and inverse. The first takes place when the direction of the movement and the position of the centre of reference coincide (approach), the second when there is opposition between the two (withdrawal).

Polarisation, then, is a particular phenomenal variable belonging to the movement; it is distinct from the movement's direction, and qualitatively different according to whether it is direct or inverse.

[9] On this question of frame of reference, see K. DUNCKER, Über induzierte Bewegung, *Psychol. Forsch.*, XIII, 1929, p. 180.

[10] It can happen that the two objects become the centres of reference for each other when they are both moving, as in the case of symmetrical movements, for example.

Nor does it seem of much importance if we limit the distance travelled by object B. This can be confirmed if exp. 12 is performed the other way round, i.e. with object B's distance being varied instead of that of object A. Perhaps the result might be different if the distances travelled by the two objects were both reduced, but we have not tried experiments of this kind.

It should be pointed out here that the movement of one of the objects can be suppressed without the impression of launching necessarily being destroyed. As will be seen later when we deal with this problem in detail, the causal impression can arise in the absence of any movement by A, if this object suddenly appears beside B at the moment when the latter begins to move, or even in the absence of any movement by B, if it disappears suddenly when it is struck by A.[7]

This question of limiting the distance of the movements becomes very important in connexion with causality in the tactile-kinaesthetic field. If my body or one of my limbs receives a blow that causes it to move, or if an object is set in motion by a blow from my arm or leg, the distance covered before it touches the skin or after it leaves it clearly cannot influence the impression. The part of the object's path which counts is limited to the depth to which the skin and the underlying tissues are indented, and does not exceed a few millimetres; yet that is sufficient to give a causal impression.[8]

2. THE RADIUS OF ACTION IN THE APPROACH AND WITHDRAWAL EFFECTS

If we are to apply the method of genetic analysis to the special characteristics of the Launching Effect which we have been considering, clearly we must divide up the total experience into its principal phases, viz. the approach of one object and the subsequent withdrawal of the other. This was done in the two following experiments.

Exp. 13. This is the same as exp. 1, except that the movement of B was suppressed, and the initial distance between the two objects was extended to 8 or 10 cm. There is thus only the movement of object A, which goes towards B and stops when it has reached it.

essential difference between the two lies in the fact that in the case of launching there is an impression that the first movement *produces* the second, while in the case of triggering there is the impression that one movement, which is otherwise clearly autonomous, *depends on* the appearance of a separate event which is its antecedent.

[7] See Chapter XV.

[8] See Chapter XIII.

that found in the case of the Launching Effect and, in addition, the absolute values are of approximately the same order.

TABLE II

The Radius of Action for the Approach and Withdrawal Effects

Speeds:	32	16	11	8	5	4	cm. per sec.
1. Subject Mi.							
Approach:	58	41		27		17	mm.
S.D.	2·2	2		2·1		1	mm.
Withdrawal:	52	29		19		12	mm.
S.D.	[illegible]	1·4		0·6		0·6	mm.
2. Subject Go.							
Approach:	60	36		22		14	mm.
S.D.	1·6	1·4		1·1		0·8	mm.
Withdrawal:	55	33		18		12	mm.
S.D.	2·1	1·4		1·1		1	mm.
3. Subject Go.[12]							
Approach:	57	30	23·8	19·6	14·2	9·4	mm.
Withdrawal:	59	33	25·9	21·8	14·3	11·3	mm.
4. Subject Mo.							
Approach: (20 readings)	87	49	28·9	21·3	14·6	10·6	mm.
Withdrawal: (20 readings)	89	49·7	30·2	22·4	15·4	11	mm.

It is worth noting that when the difference between the results obtained for the Approach Effect and for the Withdrawal Effect was significant, the higher value was always that for the Approach Effect (as in the case of the Launching Effect); but this is a point of detail which requires further verification, and I shall not dwell on it here.

The length of the radius of action certainly depends on other factors besides the speed of the movement. In particular the direction of the movement must be of great importance, for polarisation is perfect only when the moving object is going towards the centre of the motionless object.

It is probable that the length of the radius of action is also influenced by the structure of the visual field as a whole, being perhaps greater

[12] Subject Go. volunteered for a second series of experiments, the purpose of which was to obtain mean distances for a greater range of speeds. Although there was an interval of several weeks between the two series, they show remarkably similar results.

There is nothing at all surprising in this. The same thing is to be found in the field of static forms, as is well known. We may recall in this connexion the well-known example quoted by Koffka[11] of one and the same shape appearing as a square or rhombus according to the slant of the rectangle surrounding it.

Now with this qualitative difference go changes in the apparent speed of the moving object – a point which was frequently mentioned by observers. The approach and withdrawal phases often seem more rapid than the rest of the movement; and, what is more, observers very often say that they have an impression of actual progressive acceleration in the first case and deceleration in the second. Finally, when the movements are very slow, we see induced movements of the stationary object; it appears to go to meet the moving object or withdraw from it.

Now since the change in the appearance of the movements, i.e. their different polarisation, is observed only when there is a certain distance between the objects, we can apply to this distance also the same term, 'radius of action', which we used in the same sense in connexion with the Launching Effect.

Encouraged by the results of the measurements made in the earlier case, we tried to obtain similar readings in the case of the last two experiments. Once again the paths of objects A and B were limited by means of the shutters on the screen. After a few preliminary trials, in which we varied the length of the distance covered and called the subjects' attention to the difference in each case, there was no difficulty in obtaining the readings. They were required to distinguish between cases in which the moving object 'did nothing else except join the other or strike it', or 'did nothing except leave the other object', and cases in which it 'performed some movement over and above this, of an independent kind on its own account, either before going towards the other object or after leaving it'.

The results obtained are given in Table II. In this table will be found the mean distance, in millimetres, within the limits of which the impressions of approach and withdrawal made their appearance. (The standard deviations are also given for two of the four cases.) Each figure
n successive readings (or twenty where this is
f readings was made at a different speed.
peed is immediately obvious; it is similar to

KOFFKA, op. cit., p. 185.

When the movement is rapid, on the other hand, the phenomena assume a dynamic character. In the approach phase the impression is given that one of the objects '*strikes*' the other and then becomes in some way '*fused*' with it; and in the withdrawal phase the impression is that the moving object '*tears itself away*' and '*rushes off*'. Here there is a real impression of *vis viva*, of violence, which has a quite specific character, and is found also in certain cases of launching, as will be seen later.

The important issue here is in fact that of difference in speed; for the motionless object can clearly be treated as having a zero speed. Thus experiments on approach and withdrawal can be performed with both objects in motion, for instance with one moving behind the other in the same direction but at a different speed. Here again we find slight differences of impression similar to those which we have just mentioned. When the difference in speeds is small we see one of the objects simply come into contact with the other, whereas when the difference is appreciable there is impact, and the impact is more violent the greater the contrast between the speeds. The violence reaches its maximum when the two objects move rapidly towards each other and stop immediately at the moment when they meet. We then have the impression of a real *interpenetration*.

All this serves to make more precise the point which I was trying to make earlier, in connexion with the concept of activity, when I said that the impact was not merely two objects coming into contact, but a whole *process* (Chapter I, 2). Now we can see what exactly is involved. The 'impact' in the full sense, or the 'encounter' of the two objects, is a *process which begins at the boundary of the radius of action and ends at the moment when the objects are side by side*. This process forms an indivisible whole, and entirely loses its character as soon as the movement is considered in isolation from the resultant situation, that of the two objects being side by side. The same holds when the two objects are side by side at the start and one of them makes a withdrawal movement.

3. THE LAUNCHING EFFECT AND THE APPROACH AND WITHDRAWAL EFFECTS

The results recorded in the two previous sections enable us to recognise a number of obvious analogies between the Approach and Withdrawal Effects on the one hand and the Launching Effect on the other.

The objective stimulus-conditions are the same in both cases; the

when the two objects are present on their own against an uninterrupted background. It is also possible, though we cannot be quite sure about this, that the size of the objects, their shape, etc., have some influence.

In any case the very fact of polarisation of the movements is a point of considerable interest. As a general rule, a difference of state between the two objects, e.g. if one is in motion, the other at rest, operates as a powerful factor of segregation. Here we find the opposite. In certain conditions of speed, direction, and distance, the moving object links up in a special way with a motionless object. Thus the movement of an object seems to extend its influence throughout the whole area of the phenomenal field, and one cannot help thinking in this context of certain analogies from physics, especially the phenomena of induction. There too the influence of a moving object is involved – an influence which varies with distance and speed and which produces results of opposite sense according to whether another object approaches or withdraws. Such matters cannot detain us here, nor can we consider the principles underlying this phenomenon – a matter which calls at the outset for a deeper understanding of the phenomenon itself. The whole subject would be a fascinating one for further research. Even in the course of the present work we have met many different facts which are apparently related to the radius of action; indeed it seems to be an instance of a property which appears in numerous guises whenever there are complex kinematic Forms.

Let us now return to the impressions of approach and withdrawal themselves. These impressions, which possess their own special character determined by the polarisation of the movements, appear only in fixed conditions; and in the absence of these conditions, even if approaches and withdrawals are occurring objectively, no such character is presented phenomenally. Where it does show itself, however, it is certainly not a mere translation into psychological terms of some change in the distance separating two images on the retina. Indeed, when it occurs it does not always have the same appearance. It varies in particular according to the speed of the movement, as did the radius of action, and in extreme cases there can be considerable differences.

When the movement is slow, the approach gives the impression that the moving object simply goes and 'lines up with' or 'takes up position by' the other object, and forms a single block with it. In the case of withdrawal there is a splitting up of the original block, part of which simply 'leaves' the other.

analytical attitude, one can see the Approach and Withdrawal Effects when the launching experiment is performed, but this can be done only at the expense of the Launching Effect itself, which then disappears, or at least is greatly weakened.

It follows that, despite the relationship between the Launching Effect and the Approach and Withdrawal Effects, the phenomenal characteristics of the Launching Effect are very different. In particular polarisation takes a quite distinct form. It is easy to realise this if we compare the impressions in terms of which the radius of action is characterised in the two cases.

For the impressions of approach and withdrawal, it was a matter of fixing the distance from which object A 'did nothing else but join B or strike it' or the distance up to which B 'did nothing else but leave A'.

For the impression of launching it was a question of determining the distance from which object A 'simply drove B away' and the distance to which 'B was driven away by A' (or, to be more precise, the distance to which 'A drove B').

In this case we cannot help seeing a *single* action. We no longer have two distance operations – one object bumping into another and the second object moving off – but a single operation which has two aspects, viz. the operation of an *'impact-which-launches'*.* Thus all the action of launching is centred on object A, and the inversion of polarity in B's movement shows itself only in that B appears to be *pushed away* by A; that is what observers mean when they say that the impact of A *'drives* B *off'*. This clearly implies that B leaves its place and withdraws from A, but this aspect of the impression is obscured by the accentuation of the rôle of A; it is object A which completely holds the initiative. Consequently it would be a mistake to try to convey the precise nature of what we observe by saying, for example, that we see the withdrawal *brought about by the impact*. Although an impression of a passive form of movement is equally possible in theory, only an active form of movement is actually seen.

Thus the movement of A is dominant, and an internal *hierarchy* is set up in the structural organisation of the Launching Effect. This formation of a hierarchy is something essential, belonging to the very nature of the phenomenon, as will be seen in Chapter VIII, when the theory underlying the Launching Effect is discussed.

In all cases considered so far, this formation of a hierarchy was en-

* *Choc-qui-lance.* See Glossary.

difference is that to produce the Launching Effect the two sets of conditions have to be combined.

The phenomenal characteristics are also similar in several respects.

1. All these movements differ in kind from simple movements on an uninterrupted background.
2. The special qualities which they display are to be seen only when the two objects are within a certain distance of each other.
3. This distance is a function of the speed of the movement.
4. It is of the same order of size for the Launching Effect as it is for the Approach and Withdrawal Effects.

In view of this, we may justifiably claim that these phenomenal characteristics have a common basis, and that in order to study the properties of the Launching Effect we must begin by studying those of the Approach and Withdrawal Effects.

In particular we shall be able to apply to the Launching Effect the concepts of *centre of reference* and *polarisation*, and to link them up with the concept of *radius of action*. In short we are justified in claiming that we have here phenomenal properties which are homologous (i.e. which correspond in general structure).

There is, however, one major difficulty; this is that the Launching Effect, from the descriptive point of view, is very different from a mere juxtaposition of the Approach and Withdrawal Effects.

No one should suppose that this is merely an attempt to split hairs. That there really is a problem here is best shown by the actual account of our research. During the hundreds of launching experiments performed in various conditions we had noticed that there was a difference in kind between the two movements. As has already been said, this difference aroused our keen interest. Indeed, it was only after I had realised the importance of the concept of centre of reference for the Entraining Effect that I thought that the difference in question might be connected not with the Launching Effect as such, but with the fact of objective approach and withdrawal on the part of A and B. What is more, when I mentioned this hypothesis to my collaborators, who had also made a large number of observations, they were entirely sceptical. Clearly all this uncertainty would not have been possible if the launching impression were a simple conjunction of the impressions of approach and withdrawal put together.

Now certainly, after the event, and provided one adopts a sufficiently

of the motor object is substituted for the forward movement. The specific character of an impression of dilatation (like an impression of contraction) lies in the fact that one part of the object is displaced in relation to another part of the same object; the centre of reference is thus internal.[13] Nevertheless a causal impression can still appear in these conditions, as the following two experiments show.

Exp. 15. Object A, which is a red rectangle 5 mm. high and 20 mm. long, is in the centre of the slit. A black square, 5 mm. high, object B, is situated on the left of object A and 35 mm. away from it. At a given moment, the red rectangle extends towards the left at a speed of 25 cm. per sec. until it comes into contact with object B, which then withdraws from A at the same speed for a distance of about 4 cm. In a variation of this experiment, which gives even better results, the speed of object B is reduced to 7 cm. per sec.

This experiment has been tried on several trained subjects, and the impression of causality was unmistakable. Some subjects, however, could make it disappear by concentrating exclusively on the object being dilated.

Exp. 16. Object A, which is a red rectangle 5 mm. high and 10 mm. long, is at the centre of the slit. It is shut in on either side by black squares, objects B, of side 5 mm. which are 20 mm. away from object A. At a given moment object A expands symmetrically to right and left at a speed of 18 cm. per sec., until it reaches a total length of 50 mm., which brings it into contact with objects B. These then withdraw at the same speed for a distance of 2 cm.

My particular reason for quoting this experiment is that it was performed with fourteen new subjects. All of them had a clear impression of launching. Some mentioned quite spontaneously that the encounter of the two objects came about 'by chance' – an interesting remark which brings out the difference between this case and that of the Type-experiment, where the effect of polarisation is to give the movement a character of direction, or (one is almost tempted to say) of pseudo-intentionality.

Thus polarisation of the movement of object A in relation to object B is in no way essential for the appearance of the Launching Effect. This is not true of the inversion of polarity of object B. It seems essential that object B should be referred to the motor object; at any rate this is the conclusion which seems to emerge from the research described below.

[13] See A. C. SAMPAIO, op. cit., pp. 20 seq.

sured by the stimulus-conditions themselves. (An exception to this is exp. 26, described in the next section). In the Type-experiment, A is in motion while B is still; and it is well known that the movement of an object draws attention to it, making it phenomenally more important than the motionless objects which surround it. Moreover the movement of A is a movement of approach, and this confers on A a character of activity; A is *doing* something, whereas B is not. Even when both objects are moving in the same direction from the beginning, as happens in the case of 'launching-in-flight'* (see the following section), it is still the approach movement which counts, and this is necessarily a movement by A, since it is A which approaches B. The movement of withdrawal by B, on the other hand, begins only after they have come into contact and therefore is always later than the movement of A in all these experiments. In short, the movement of A dominates that of B in virtue of the importance both of the part which it plays and of its earlier position in time. We shall call this hierarchy the *hierarchy of priority*, to differentiate it from the *hierarchy of speeds*, which is concerned with the relationship between the speeds of approach and withdrawal. With this second hierarchy we shall be concerned later.

The difference in polarisation which marks the contrast between the Approach and Withdrawal Effects is also found in the Launching Effect, which, as we have just seen, is genetically derived from them. In the first stage of the experiment it is object B which forms the centre of reference for the movement of object A, whereas in the second stage it is object A which plays this part for the movement of object B. Thus the centre of reference changes at the point of impact, and this shows clearly the *polarising function* of the objects here.

Although this change occurs in many cases of launching, it would nevertheless be a mistake to think that it is an essential feature of the structural organisation of this form of causality. No such change occurs in launching-by-expulsion. When a javelin is thrown, for instance, the two objects (the arm and the javelin) actually begin moving together before one of them detaches itself from the other; thus there is no approach, and the movement of the motor object is not polarised in relation to the object which it carries along with it (see Chapters X and XI).

Moreover the change in the centres of reference is not even found in every case of launching-by-striking. This can be seen if a dilatation

* *Lancement au vol*. See also Glossary.

accurate, from a phenomenal point of view, to speak of an 'entry' and an 'exit' made by the moving object. We simply see the object *go past*, either in or behind the tunnel. The integration, in a total unity, of the two visible phases of the movement ensures simultaneously the retention of direct polarisation, the segregation of the object from the tunnel, and the permanence of the object which performs the movement.

When, on the other hand, the entry-exit interval becomes longer, there comes a time when the continuity of the movement is broken; and among the numerous phenomena that can be observed in these conditions, there is sometimes the impression of launching, the impression that 'the object which enters the tunnel drives out another which was hidden there'.

It seems from this observation that *segregation of the movements is a prior condition* necessary for the inversion of polarity; the character of 'arising out of' cannot be produced except in the case of movements which *begin* at the point towards which they are polarised. In other words it is only in these conditions that the movement can be integrated in one whole with the object which forms its point of departure. This important conclusion, which agrees perfectly with a whole mass of experimental data and also with the general theory of the causal impression, shows that among the various functions assumed by the objects in the Type-experiment of launching, the function of segregation has priority in importance over that of polarisation.

(ii) *Launching-in-flight*

When two objects travel, one behind the other, in the same direction but at different speeds, their movements can give rise to many varieties of impression. When the speeds are nearly the same the impression is that of a pair of objects in movement. The similarity of movement makes the objects appear as a unity, even when they are a fair distance apart, and provided the distance travelled is not too great it also obscures the difference in speed. When the difference of speed is increased, on the other hand, there comes a time when we find either the Approach Effect or the Withdrawal Effect (according to the relative position of the objects).

In view of this, it becomes easy to check the hypothesis that the Launching Effect of the Type-experiment is genetically linked with the Approach and Withdrawal Effects. All we need to do is to produce a

4. THE INVERSION OF POLARITY IN THE LAUNCHING EFFECT

The principal object of the very varied experiments which will be described in this section was to examine how important it is for the production of the Launching Effect that there should be polarisation of the movements, and especially inverse polarisation of the second movement.[14] As was to be expected, however, the experiments have also thrown further light on some points of detail; and even where the results were negative, they enable us to fill in the gaps in the evidence which we have so far collected.

The intention in the first group of experiments (sections i and ii) was to find out whether a causal impression would be obtained if an objective approach and an objective withdrawal were juxtaposed in conditions somewhat different from those studied above.

(i) *The case of the Tunnel Effect*

We wanted in particular to find out if, in spite of the results recorded in Chapter III, a causal impression could be obtained, by means of a suitable device, in the case of the movements of a single object. At the time when our research was in its early stages this question was at any rate not an absurd one.

The obvious procedure was to introduce a fixed object on the course covered by the moving object. The latter would first approach this object and then withdraw from it. Such an experiment, as we know, generally gives the impression of one object simply passing over the other, and the movement does not undergo any change of character while this is going on.

As this result seemed to conflict with what we said earlier about the polarisation of the movements, we undertook some special research on the Tunnel Effect in order to clarify the situation.[15] To give full details here would take too long; but the main conclusion to be drawn from the results is that the movement remains continuous when the interval between the entry of the object into the tunnel and its exit is sufficiently near the time taken to travel the length of the tunnel at a uniform speed. In this case the tunnel is a mere accessory which has nothing to do with the movement. Thus it would be in-

[14] We are concerned in this section only with launching-by-striking, as it occurs in conditions similar to those of exp. 1.

[15] Data on this subject occur in A. C. SAMPAIO, op. cit., pp. 27 seq.

The same result is obtained when B has the same speed before and after the impact, e.g. if A moves at 29 cm. per sec. and B at 15 cm. per sec. throughout.

It is even possible to produce the paradoxical case where the movement of B is slowed down by the impact of an object of the same apparent mass travelling more rapidly. Thus when A moves at 30 cm. per sec., and B moves at 15 cm. per sec. before the impact but continues its movement at a speed of 7·5 cm. per sec. after A comes to a halt, a perfect launching impression can be obtained.

This is the first paradoxical case which we have had occasion to describe; others will be mentioned later. Such cases are particularly interesting in that they show that causal impressions arise as soon as the psychological conditions of structural organisation are fulfilled, and indeed that they can arise even in situations where we know from past experience that a causal impression is a downright impossibility.

In a second experiment, object A continues on its course after striking object B and setting it in motion.

Exp. 18. Objects A and B are 5 cm. apart. A sets off at a speed of 40 cm. per sec. and joins B which is at rest. Then B sets off in the same direction at a speed of 29 cm. per sec., while A continues to move at one of the following speeds – 27, 25, 22, 15, or 7 cm. per sec. The eventual distances between the two objects ranged from 15 to 95 mm. in the various cases.

Here, too, as soon as the speeds after the impact are sufficiently different for the impression to be given that B is withdrawing from A – that is to say, when the combination is e.g. 29 and 7 cm. per sec. – the Launching Effect is quite clear. The movement of object A is continuous; that part of the movement which follows the impact is no longer divided off from the preceding part and appears to be merely an unimportant sequel to it.[17]

[17] The difference in this connexion between the last two experiments is striking. In exp. 17 the movement of object B has the appearance of being broken as a result of the impact, whereas in exp. 18 A's movement still appears to be continuous. It is tempting to look for the explanation of this difference in terms of the inversion of polarity which characterises B's movement but not that of A. Such an explanation is unsatisfactory, however, since, as we saw in the case of the Tunnel Effect, there cannot be inversion of polarity unless there is *already* segregation. It seems rather to be the dominance of A which is influential; in fact if we upset the hierarchy by concentrating on object B in exp. 17, this is sufficient to ensure the continuity of its movement and the disappearance of the Launching Effect. This is particularly successful when the movement is objectively uniform and fairly rapid (10 cm. per sec. minimum).

combination such that one of the objects approaches the other until it comes in contact with it, and the second then withdraws from the first. It will then be possible to verify whether the impression of launching is produced as soon as the differences in speed reach the level necessary for the appearance of simple approach and withdrawal on their own. This is the purpose of the three following experiments. Despite their similarity, each is instructive in its own way.

In the first, object A pursues object B, joins it, and then stops, while object B continues its course.

Exp. 17. Objects A and B, which are at some distance from each other (the distance ranged from 15 to 95 mm.), begin to move simultaneously in the same direction. A moves at a speed of 29 cm. per sec. and B at one of the following speeds – 27, 25, 22, 15, or 7 cm. per sec. A stops after coming into contact with B, but B continues to move, changing to a speed of 40 cm. per sec.

The impression of approach is quite clear for the combinations 29/15 or 29/7 cm. per sec., and the impression of launching is likewise perfect in these conditions – quite as good as in the case when B is still. The impact literally cuts the movement of B into two parts. The part which precedes the impact seems quite divorced from the other; it is a 'side-show' on the fringe of the performance as a whole.

If the difference in speed is less it is quite a different matter. When the combinations are 29/27 or 29/25 cm. per sec., the movement of object B is continuous, and during the first stage we merely see A 'running along behind B', 'pursuing' it (which, we may note in passing, is a quite specific impression), or we see a group of objects in motion, of which one stops at a given moment. There is no longer any causal impression.

When the intermediate combination is used, the results are ambiguous; sometimes there is causality, sometimes not.

When the absolute speed is slower, a ratio of speeds of as little as 1 : 1·5 gives good launching effects. This occurs, for instance, when A and B have speeds of 10 and 7 cm. per sec. respectively before the impact, and B has a speed of 13 cm. per sec. after the impact.[16]

[16] It should be noted that Weber's law applies only imperfectly here. If the ratio between the speeds is kept constant, we find, in the range of speeds used in our experiments, that when the absolute speed is lower the apparent difference between the two movements is greater. In planning and interpreting experiments this is a point which clearly needs to be taken into account.

by a simple lengthening of the distances which the two objects travel. This results in the substitution of the Relay Effect for the Launching Effect (see p. 57).

Two other groups of experiments are particularly relevant in this context. In the first an attempt was made to give the movement of object B a centre of reference other than object A, and thus abolish the inversion of its polarity. In the second the purpose was rather to prevent the integration in a single whole of the movements of approach and withdrawal performed respectively by the two objects. In both cases, if our forecasts were correct, the Launching Effect would necessarily disappear.

We made a number of attempts to modify the polarisation of the movement of object B. The first, which proved ineffective, consisted in putting a third fairly large object at the end of object B's path, or alternatively outlining with a coloured pencil the route on which B was to travel. Such expedients, however, were not sufficient to modify the polarisation of the movement; for the ascendancy exerted by the fact of the impact is much too strong to be counterbalanced by the mere presence of static objects.

In other experiments we introduced various combinations of *movements*. I shall mention four as examples.

Exp. 20. This is the same as exp. 1, with the addition, to the right of object B, of a series of five small squares of the same colour and same dimensions as B, and separated from each other by a minimum distance of 1·5 mm. This forms a closely united whole, a block of six pieces, of which the first, at the left, is object B.

At the moment when object A begins its movement, the last square on the right also begins to move, and goes towards the right; then the others follow it in turn while A is moving, so that B, the last in the line, begins its movement at the exact moment when A has come up beside it. The speeds range from 10 to 35 cm. per sec.

To any unsophisticated observer, and even to any subject who looks uncritically at the total situation, there is no Launching Effect in this experiment. The movement of B is in fact integrated in the series of successive movements of the 'pieces' in the block; the movement of A is merely accessory, and has nothing to do with the sliding of the block as a whole. All the same it is only right to point out that the very conditions of the experiment tend to turn the observer's attention towards the centre of the block; and this, as we saw earlier, can be responsible for the disappearance of the Launching Effect (see exp. 7, p. 47).

When the difference is less, on the other hand, as in the case of the combinations 29/27 and 29/25 cm. per sec., a remarkable phenomenon appears – the *Launching Effect gives way to the Entraining Effect* of exp. 2; object A seems to *carry off* object B, and the greater the absolute speed the clearer becomes the impression. This is a very interestng fact, and we shall return to it later; it shows that the two cases of causality that we have chosen as types are closely related, despite the differences between them, and that it is possible to pass progressively from one to the other.

Finally, a third experiment combines the two previous ones; object A pursues object B, joins it, and immediately slackens speed while B increases its speed.

Exp. 19. Objects A and B are 3 cm. apart. They begin to move simultaneously in the same direction, A at a speed of 30 cm. per sec., B at a speed of 15 cm. per sec. After the impact they both continue to move in the same direction, A at a speed of 15 cm. per sec., B at a speed of 30 cm. per sec.

We find the same evidence here as in the former experiments that the conditions which give the impressions of approach and withdrawal are the same as those which produce the Launching Effect. The Launching Effect is plainly to be seen here, and is all the more marked as the difference in speeds becomes more apparent, a result which can easily be achieved if we reduce the speeds to the absolute values of 10 and 5 cm. per sec. When the difference is slight, on the other hand, the Launching Effect disappears.

In addition, when both objects are continuously in motion, as in these experiments, it is often possible to observe another curious occurrence – a dissociation of the systems of reference. In this case we see not only one object launching another, but also both objects apparently taking part in a joint forward movement. For example, one of the observers said that it was as if 'the scene of the impact was taking place on a moving belt'.

(iii) *Camouflage experiments*

This type of experiment, as is well known, consists in complicating a given combination of stimuli by adding new elements to them, thus modifying to a greater or lesser extent the structural organisation of the corresponding perception.

The first case to be mentioned here is the camouflage often achieved

up on itself independently of the previous movement of A. Sometimes, however, A's movement seemed to trigger off the contraction. Once it was started, however, it remained autonomous. The speed is of considerable importance in this connexion. The best results were given for the following combinations – rectangle 23 mm. long, speed of object A 20 cm. per sec., speed of each side of B 5·5 cm. per sec.; rectangle 33 mm. long, speed of A 33 cm. per sec., speed of B 24 cm. per sec.

When the speeds are greater (e.g. 30 or 40 cm. per sec. for object A in exp. 22 (*a*) above), the encounter between the two objects appears as a more violent impact. This impact then becomes dominant, and the influence of triggering becomes clearer.

The following experiment is the exact converse of exp. 16, p. 67.

Exp. 23. Object B is a rectangle 5 mm. high and 50 mm. long in the centre of the slit. It is shut in on either side by two black squares of side 5 mm. (objects A), which are 20 mm. away from the ends of B. Objects A begin to move at the same time towards B at a speed of 18 cm. per sec., and stop at the moment when they reach it. B then contracts symmetrically at the same speed and reduces its length to 10 cm.

The experiment was tried with twelve inexperienced subjects. Eight of them asserted that the contraction of B was absolutely independent of its contact with objects A, or merely triggered off but not produced by it. The other four seemed to have a causal impression; the account they gave was in effect that objects A 'stove in' the rectangle.

This result is particularly striking if we compare it with exp. 16, which every time gave the launching impression. It is evident from this how much more important polarisation is for the movement of the 'passive' object B than it is for that of the 'active' object A.

There are, it is true, the four subjects who had a clear impression of causality. This seems to show that inversion of polarity is not essential to the Launching Effect. We should, however, be cautious in ascribing importance to these cases. The results are flatly contradicted by experienced observers. These not only failed to obtain anything nearer a causal impression than an impression of triggering, but even when they tried to get one by changing their approach they did not succeed.

In the face of this there are two possible hypotheses. One is that the expressions used by the subjects were inadequate to describe their impressions, as often happens with new subjects. On the assumption,

Moreover it reappears fairly readily when the point of impact is fixated, especially if the speed is reduced to 10 or 15 cm. per sec.

Exp. 21. This is the same as exp. 1 except that before A begins to move B performs a continuous series of to-and-fro movements between its ordinary stopping-place and its position in the centre of the slit. These movements are made at a speed of 30 cm. per sec. It is so arranged that A, when its turn comes, moves off at the same speed as B, and is timed to reach the point of impact at the exact moment when B arrives there at the end of its last journey; A then comes to a halt and B goes back to its stopping-place.

In this case also the Launching Effect disappears when observers look at the situation as a whole. The last phase of B's movement is linked with the previous phases, which clearly took place in relation to the frame of reference provided by the screen; the total situation formed by these phases seemed entirely independent of the movement performed by A. Concentration on the point of impact, however, can produce isolation of the last phase, and then, once again, the Launching Effect reappears.

Other experiments have been carried out in which we made use of the impression of contraction which we have already met in expts. 15 and 16. In these cases the dilatation of an object was used to bring about the launching.

Exp. 22. This is the same as exp. 1 except that object B is replaced by a long rectangle. At the moment when object A comes into contact with it and stops, the rectangle, without moving from its position, contracts at both ends simultaneously, until it is reduced to a small square of side 5 mm. some distance away from object A.

In one of our experiments, (*a*), the rectangle was 23 mm. long, and after the contraction the square was 9 mm. away from object A. In another experiment, (*b*), it was 33 mm. long and the final distance was 14 mm.

The significance of this experiment can be easily understood. When object A reaches B, B appears to contract; that is equivalent to saying that the side of B touched by A moves phenomenally in relation to the opposite side. Thus A is not the centre of reference of this movement, and the Launching Effect must disappear.

This experiment, like those before it, was tried with experienced subjects. They had no impression of launching. In optimum conditions they generally saw A come up beside B, which then contracted or folded

A, as in the Type-experiment; C disappears and then reappears on the other side of A, continues until it reaches the position where A began, and stops there.

The experiment as a whole is easy to understand from the following diagram:

Initial positions:	A		B		C
Intermediate positions:		A	B	C	
Final positions:	C		A		B

This experiment can be thought of as the Type-launching experiment, with the addition of the movement of a third object travelling at the same speed as A and B but in the opposite direction, and going behind them at the moment of impact.

This time all trace of launching has disappeared, and whatever attitude is adopted it seems impossible to recover it.

The impressions vary with the speed and with the position of the point fixated. When this point coincides with object B, the usual impression is that of two objects at the ends, each performing a to-and-fro movement in relation to an object in the centre of their path. A's and B's phases of immobilisation at the centre are linked, and there appears to be a permanent object in this position. This object moves slightly and changes colour when the other objects reach it, but that in no way affects its identity. The objects at both ends also seem to remain the same during their respective journeys and returns. The unity of movement once again results in the permanence of the object, despite the permutation of objects A and C on the one side and C and B on the other, and despite the change in the colour of C and B.

Sometimes observers see the two objects at the ends go towards each other and cross at the point where a third is to be found in the centre of their path (the Tunnel Effect of exp. 7). In this case the physical identity and apparent identity of object C correspond, but A and P change places.

Finally, observers sometimes receive the impression that the two end-objects are rotating in the third dimension round a permanent central object. In that case the apparent distance separating the original objects remains constant. Such movement combinations have already been described and thoroughly studied by Metzger, and there is no need for me to discuss them in further detail here.[18]

Thus the modification in the experimental conditions resulted in the

[18] W. METZGER, Beobachtungen über phänomenale Identität, passim.

however, that what they said was accurate, there is also the possibility that their perceptions were structured differently, and in particular that these subjects did not see the shortening of the rectangle as a *contraction*. This possibility should not be excluded *a priori*, for some very recent observations have shown us that a shortening can give rise to different perceptual organisations, some of which consist phenomenally only of a change of position of the two ends or the two halves of the figure in such a way that they seem to slide on top of one another. It is obvious that the polarity in the case of movements of this kind could be inverted, and that in these conditions the impression of launching would not necessarily be destroyed.

In view of all this, we thought it wise, as a matter of principle, to abide by the observations of the experienced subjects, and claim, at least until we have further information, that the impression of contraction is incompatible with the Launching Effect. Thus it is impossible to see the impact of one object *produce* the contraction of another.

This discussion raises a somewhat difficult point which will be mentioned later in connexion with the problem of propulsion and which deserves detailed study.

The last group of experiments are again a group of three. They are similar to each other, but all of them present features that are of interest from different points of view. The basic principle in all three was a modification of Type-experiment in such a way that the two constituent movements, although still polarised in the same way as in the Type-experiment and following each other in the same spatio-temporal conditions, were not linked together. To obtain this result we made use of the fact of symmetry. A further reason for adopting this procedure was that, in experiments involving symmetrical movements of two objects, these objects act as centres of reference for each other's movements, or rather the movements have a common centre of reference which lies between the objects.

Exp. 24. This is the same as exp. 1, but in addition to A and B there is a third object C, coloured black. At the beginning of the experiment this object is in a similar position, relative to B, as is object A, but on the opposite side. It begins to move towards B at the same time as A and at the same speed of 30 to 40 cm. per sec.; thus they reach B simultaneously.

At this moment the three objects are side by side in the order A, B, C. A then comes to a halt while B begins to move and withdraws from

seen later, the kinematic unity necessary for an impression of this kind is difficult to achieve.

It is easy to show that the symmetry as such is the operative factor here. Any modification which alters this symmetry even to a very small extent brings about the reappearance of the Launching Effect. In order to achieve this we need only slow down object A's return journey to a speed of 10 cm. per sec., while keeping A's outward movement and all B's movement at a speed of 40 cm. per sec. A similar result, though not such a good one, is also obtained when the movement of B is reduced to 10 cm. per sec. while the two parts of A's movement are kept at 40 cm. per sec., which of course favours the structure of to-and-fro movement.

Finally, in a concluding experiment, object B performs a to-and-fro movement.

Exp. 26. This is the same as exp. 1, except that object B, instead of being motionless in the centre during the movement of object A, goes to meet it.

Objects A and B, which are 10 cm. apart, begin to move simultaneously at a speed of from 20 to 30 cm. per sec., and go towards one another. At the moment when they come into contact, object A stops, while object B returns to its starting-place at the same speed.

The seven subjects who volunteered for this experiment received an immediate impression of launching; in this case it is the blow dealt by object A that sends B back again. B's withdrawal movement is cut off from the previous phase of its movement, as in some cases of Launching-in-flight which we examined earlier (pp. 69 seq.).

appearance of kinematic Forms in which symmetry was the dominant factor. Consequently the impressions which developed were always those of two similar movements performed at the same time by the two objects – to-and-fro movements in the first case, movements along the whole length of the path in the crossing-over case, and rotation when the third dimension was involved. This of course excluded any possibility of launching.

The following experiment is particularly interesting because it does not seem, *a priori*, that the change produced in the stimulus-conditions ought to alter the causal impression; this change is, in fact, limited to the introduction of a to-and-fro movement by object A.

Exp. 25. This is the same as exp. 1, except that object A returns to its starting-point after it reaches object B, at the same time as B begins its own movement. The speed of the movements is from 30 to 40 cm. per sec.

In these conditions we might expect to see object A perform a to-and-fro movement in relation to B, in the course of which it deals B a blow which sets it in motion or launches it. This is not in fact what happens. Object A simply goes and touches B, and then both objects withdraw. This forms a new scene – the important one, to which the previous approach was only an introduction. The Launching Effect disappears completely, and the impact is replaced by a contact which sometimes gives the impression of triggering off the withdrawal movements of both objects.

This is a very odd result. In fact in this experiment we find, even on the phenomenal plane, the juxtaposition of two movements (the approach of A and the withdrawal of B) in conditions of space, time, and polarisation which are like those which characterise the Launching Effect; yet a different impression is forced on us. The reason clearly is that these two movements are not integrated in one whole. This brings out admirably the necessity for integration if the Launching Effect is to appear, a point which we shall be studying in Chapter VI.

In the present experiment integration takes place along different lines. It is the two symmetrical and simultaneous movements which are linked together, and which on the other hand are relatively detached from the first movement of object A. Conditions thus favour the symmetrical structure rather than that of launching, and they do so all the more because in the present case a structure of launching could be produced only by an impression of to-and-fro movement. As will be

It is from this point of view only that I have considered these experiments; but it is perhaps worth pointing out that a study of them also enables us to make a number of very interesting comments on more general questions concerning the perception of movement. I have purposely avoided stopping to discuss these questions so as not to interrupt the main line of thought running through this book.

object A was moving at the same time. None the less this is a strange occurrence, the more so in that it is not possible by modifying one's observational attitude to eliminate the Launching Effect without at the same time destroying the impression of symmetry. The impression which takes the place of the Launching Effect in these conditions is in fact that of a to-and-fro movement by B in the course of which it meets A – A meanwhile having been performing an independent movement.

The Launching Effect is considerably accentuated when B's return movement is a third or a quarter the speed of its approach movement. On the other hand the structure of to-and-fro movement imposes itself when the two parts of B's movement have the same speed, and that speed is three or four times as great as that of A. This is, of course, what one might expect.

This experiment has something further of interest to offer in that it shows a feature that is unique among all the experiments which we have conducted. We saw earlier that the structure of the Launching Effect involved the setting up of an internal hierarchy, and that this hierarchisation was usually assured from the first phase of the experiment by the stimulus-conditions themselves. Now in the present case this is not so. The two objects approach each other symmetrically, and there is no objective reason why one should dominate the other. We must, therefore, conclude that the dominance in this case is one of purely subjective origin, and that it is an aspect of a structural organisation which emerges of its own accord in response to a given system of stimuli, as the most favoured Form. We can infer from this that, even though the existence of 'objective' factors of dominance influences the structure in favour of the Launching Effect, nevertheless the presence of these factors is not indispensable for its appearance.

This experiment was performed by the disc method. We cannot, therefore, exclude the possibility that the periodic repetition of the stimuli played some part in the establishment of a fixed type of organisation.

The series of control-experiments described in this section, if taken together, fully confirm the theory which our comparison of the properties of the Launching Effect with those of the Approach and Withdrawal Effects seemed to suggest. In particular, *inverse polarisation of the movement of the projectile is apparently an essential characteristic of the causal impression of launching.*

In these conditions, too, there are no doubt gradual differences which could be determined by future research. It seems certain, for instance, that shapes placed on their sides and pointing in the direction of the movement (especially in the case of object B) favour the Launching Effect, and make the impression better. One of the most striking cases of this occurs when A is a vertical line and B a horizontal one.

The Launching Effect, then, is largely independent of the shape, size, and colour of the objects. It is also independent of what may be called their phenomenal nature.

The two methods, the disc method and the projection method, showed considerable differences in this connexion.

In the case of the disc method the speed of rotation and the observation-distance were such that every microstructural detail of the surface of the paper disappeared. Consequently the two objects and their background seemed perfectly homogeneous. In addition, since the movement of the disc is not perceptible when a sufficiently small screen is used or when observation is made through a tube, the impression obtained of the objects is like that of little squares of thin cardboard or little coloured patches moving in front of a completely unified background; the colours of these patches clearly present the appearance of surface colours, or 'Oberflächefarben'.

If the projection method is used the result is different. When figures are projected on to an opaque screen, or particularly when they are projected on to a transparent screen, they have more the quality of film colours, 'Flächefarben', and the objects appear as simple 'coloured shapes'.

The Launching Effect is found in both types of experiment, and occurs irrespective of whether the subjects have made thousands of observations or are observing for the first time.

The differences, if any, are again gradual. In my personal opinion and that of some of my collaborators, the effect is better in the case of the disc method. Possibly, however, this is due to accessory circumstances such as the presence of the slit, etc. Other subjects who are excellent observers hold the opposite opinion, so that once again it would be necessary to have recourse to statistical research to determine this point of detail.

There can be no doubt, then, that the 'phenomenal nature' of the objects is of little importance in the production of the causal impression. That is an important conclusion; and we have, therefore, tried to make a countercheck by further tests.

CHAPTER V

The Phenomenal Aspect of the Objects

During the course of the experiments described so far, it was apparent at various times that a difference of colour in the objects does not have any appreciable influence on the production of causal impressions. The same is also true of differences in size and shape.

In the case of size in particular we have performed various experiments on launching (using the projection method) in which the objects were of different dimensions. The objects used were circles whose diameters varied from 2 to 28 cm.; and the ratio of the surface areas could thus be as high as 1:200. The observation-distance was from 2·50 to 3 metres. In the normal conditions for these experiments – in particular when the point of impact is fixated throughout – the Launching Effect is produced consistently. Sometimes, admittedly, there are differences of degree in this impression, and there are also individual variations between subjects. Some of them mentioned, for example, that the Launching Effect was 'better' when A was bigger than B, while others saw no such difference. Perhaps if the experiments were performed many times they might reveal certain systematic influences; but in any case – and this is what matters from our point of view – no difference in size, within the limits used, however considerable the disproportion between the objects (and the logical absurdity which could result), is found to be absolutely incompatible with the Launching Effect. In spite of this, however, we should remember in this connexion the well-known fact that the size of objects exerts an influence on their apparent speed, and that this influence may to some extent be operative here in altering the apparent relative speeds of each of the two objects. This may make a considerable difference to the Launching Effect, as will be seen later.

The same is true of differences in shape. We have used squares, circles, semi-circles put together at the moment of impact, rhombi, vertical and horizontal lines (10 cm. long), triangles on their sides and pointing in the direction of the movement, and so on. We have produced all sorts of combinations of these shapes, with one shape forming object A, and a different one as object B. As before, the Launching Effect was produced regularly.

In other respects everything was the same as in the ordinary experiments. The ball and the bright-coloured circle started some distance away from each other; the ball began to move towards the circle and stopped at the moment when it came into contact with it. At this moment the circle began to move.

The observations were made at different distances, and even at the very short distance of 50 cm., and observers always fixated the point of impact. The room as a whole was well lit, and the phenomenal difference was thus quite plain.

The result of this experiment is absolutely clear. The Launching Effect can be quite as evident, quite as 'good', as in the most successful experiments described so far.

This fact has been confirmed by a large number of people, and in particular by at least a dozen subjects who were experienced scientific observers in different fields.

From all this we may conclude that *the causal impression which appears in the Launching Effect is independent in principle* (if we disregard the possibility of gradual differences) *of the phenomenal aspect of the objects.*

This is a very important finding. In the first place it is a direct reply to the view widely held by outsiders that it would be absurd to try to produce a true impression of mechanical causality without using 'real' substantial objects.

Secondly it shows that the 'status' of the objects in no way alters the impression of causality, and that the fact that the objects belong to different 'worlds', as I have just called them, does not necessarily act as a segregative factor in these experiments.

Moreover – and this is a claim which we have made already – the causal impression persists even in the face of direct opposition from the facts of past experience. We know perfectly well that a 'real' ball cannot 'drive away' or 'launch' a reflected image or a shadow. It is in defiance of this knowledge that we actually *see* the launching of one by the other. Moreover all the causal impressions mentioned in this book have

arm of very light material, 35 cm. long. The ball was fastened to the end of it, and was thus 45 cm. from the centre of rotation of the apparatus. It was thus possible, by means of the toothed segment, to make the ball move evenly over a fixed distance, and start the movement of projector B at the moment when the ball arrived at the end of its course.

The image of the circle produced by projector B was reflected by an inclined mirror situated beside the observer. It was possible to hide all the accessories by means of a screen of appropriate size.

In the Type-experiments, when they are carried out by the projection method, the focus of the images was generally exact, with the result that the contour of the objects was perfectly clear. This, as we know, gives them the appearance of 'things'. It was interesting to examine the result of blurring the outline.

Exp. 27. This is the Type-experiment of launching, except that through bad focusing the images appear as blurred circular masses, like round coloured patches of mist, with imprecise edges merging into the penumbra. The diameter of the circles was 30 mm., the speed from 30 to 50 cm. per sec., and the observation distance from 1·5 to 2·5 metres. The background was faintly illuminated.

The 'thing'-like character of the objects is greatly reduced in these conditions; the impression is suggestive of something produced by two somewhat indistinct shadows. In spite of this, however, the Launching Effect persists.

Another experiment was then carried out which we thought, if successful, would necessarily be conclusive. It was a question of discovering whether we could produce the Launching Effect by using a 'real' substantial thing of three dimensions for one object and a bright-coloured 'image' or simple shape, as in a film, for the other. We were extremely sceptical as to the possibility of getting any positive result in this experiment; in fact it seemed to us, *a priori*, that innumerable factors might intervene and modify the structural organisation of what is perceived! In particular we thought that the enormous difference between the phenomenal appearance of the two objects must have a segregative influence and make them appear to belong, as it were, to different 'worlds'.

Exp. 28. Object A consisted of a *wooden ball* 15 mm. in diameter. It was free to move along a horizontal slit 60 mm. long and 15 mm. high, cut in a cardboard screen and with its ends rounded in such a way that it exactly held the ball when it reached the end of its course. The centre of the ball was level with the slit.

Object B consisted of a *small bright-coloured circle* 10 mm. in diameter, projected on to the screen in such a way that it grazed the end of the slit when the 'impact' occurred.

The ball travelled a distance of 2 or 3 cm. at a speed of 10 cm. per sec.; the bright-coloured circle travelled a distance of about 10 cm. at a speed of 8·5 cm. per sec.[1]

[1] To produce the movement of the ball the following technical device was used. The table of projector A (see p. 35) was fitted with a rigid horizontal

SUMMARY NO. I

Résumé of Chapters III, IV, and V

From the experiments described so far there is sufficient evidence to show clearly that the Launching Effect (in the case of launching-by-striking) must be considered as a perceptual Form (Gestalt). It is characterised by a specific internal structure, and occurs when there are certain definite conditions of stimulation and reception. Like all perceptual Forms it disappears as a result of appropriate modifications in the stimulus-conditions, or as a result of changes in the observer's attitude which lead to the substitution of a different Form.

Certain groupings of stimuli are sufficient in themselves. When these occur the causal impression is distinctly favoured; it is forced on us, and withstands fairly considerable changes of attitude. Other groupings, again, are ambiguous, and the impressions appear to be far more dependent on these changes of attitude.

All these conditions are controlled by the general laws of the structural organisation of perceptions; and this enables us on occasions to make the causal impression appear in conditions which, from the point of view of common-sense mechanics, are paradoxical.

It is therefore quite out of the question to regard the causal aspect of the Launching Effect as due to an 'act of interpretation' on our part, or to suppose that, under the influence of past experience or in some other way, we ourselves invest certain basic impressions of movement with a 'meaning'. On the contrary there is actual *perception* of causality, in the same sense that there is perception of shapes, movements, and so on. These expressions are logically similar; and in each case it is a question of specific phenomenal data, whose appearance is linked with the action of a particular system of sensory stimulation.

In the preceding chapters the study of the internal structure of the Launching Effect has been limited to an examination of the part played by the objects as factors in the total organisation.

The first part which they play is that of maintaining the distinction between the two movements which comprise the Launching Effect, i.e. the movement of the object which delivers the blow and that of the

occurred in the presence of observers who knew perfectly well that 'in reality' no causal influence was operating.

The ideas developed in this chapter point the way to an important conclusion. If the causal impression can still be produced irrespective, more or less, of the phenomenal character of the objects, if it does not, therefore, depend on their particular nature, that is because production of the causal impression is dependent simply on the presence of objects of *some* kind. In other words, in the Launching Effect the part played by the objects – as far as present purposes are concerned – is to act as *factors of structural organisation*, i.e. as *segregative and polarising agents*. The experiment shows that this part can be played by objects of any kind whatsoever.

thus acts as *centre of reference* for this movement. This gives the movement a special character which I call its *polarisation*. Polarisation can be of two different sorts according to the position of the centre of reference. When the centre of reference and the direction of movement coincide there is direct polarisation, and the movement has the appearance of 'going towards' (Approach Effect); in the opposite case there is inverse polarisation, and the movement has the appearance of 'coming from' (Withdrawal Effect). This relationship between the two objects, however, exists, once again, only within certain spatial limits, beyond which the movement remains unaffected by the presence of the motionless object; the latter is then situated beyond the *radius of action*. The size of the radius of action is about the same as for the Launching Effect, and in this case too it varies proportionally with the speed.

There are thus very close analogies between the complex phenomenon of launching and the simplified ones of approach and withdrawal, and this throws some light on certain characteristics of launching. Indeed it is reasonable to suppose that these characteristics derive genetically from those which are found in approach and withdrawal. Consequently we may apply to the structure of the Launching Effect the important concepts of centre of reference and polarisation.

Now in the Type-experiment of launching the two objects act in turn as centres of reference for their respective movements. There is therefore a change of centre of reference at the point of impact, and the two objects act alternately as *polarisers* of the movements. This is the second function which they fulfil in the Launching Effect.

object launched. This is important, since the conditions necessary for the production of the causal impression tend to destroy the distinction between the two and fuse them into a single movement, as is proved by several experiments described above.

Thus other factors must intervene to counterbalance this influence; and our experiments show that distinguishing between the movements is bound up with segregating the *objects* which perform the movements, and ultimately with the conditions which ensure this segregation. From this point of view, then, the objects exert a *segregative* influence on the movements. This is their first function in the Launching Effect.

Now the movements which occur in the Launching Effect differ from each other in their phenomenal character, even though they are physically alike. This special character, possessed by each, is to be seen only for a certain distance on either side of the impact. It is only within the limits of these distances that the movements 'have something to do with' the launching; beyond these limits they are just plain movements – simple changes of position in the spatial frame of the whole.

These distances, to which we have given the name *radii of action*, are a function of the speed of the objects and increase proportionally with it. They set certain limits, both spatial and temporal, to the action of launching. The action in effect begins, from the phenomenal point of view, only from the moment when object A has approached sufficiently near to object B for B to be within its radius of action, and it ends when B, in departing, passes beyond the limit of *its* radius of action. This distance is the *active period*, the causal period in the strict sense, which, expressed numerically, is scarcely more than a few centimetres in length, and lasts only a fraction of a second – amounts which are easy to measure if a suitable method is used.

A reduction of the extent of the movement within the limits of the radius of action does not alter the Launching Effect at all. When the extent of the movements is very much greater than the radius of action, the Launching Effect tends to give place to the Relay Effect.

The specific characteristics of the Launching Effect can be studied by the method of genetic analysis. This involves comparing these characteristics with those of each of the phases of launching when these are produced in isolation.

Here, too, in certain conditions, we find that the movement of the moving object is phenomenally related to the motionless object, which

CHAPTER VI

Spatio-Temporal Integration

In investigating the conditions in which the Launching Effect appears, we have so far paid particular attention to the ways in which the two movements are distinguished. We must now examine the conditions as a result of which they become united in the total operation of launching. They are of three kinds, viz. conditions of space, time, and speed, and will be studied in the next two chapters.

1. TEMPORAL UNITY

Even the most casual observations show that if there is to be a causal impression it is essential that the second movement should follow the first quickly; indeed this is so obvious that any research on the question may seem superfluous. There is nevertheless an interesting problem here. As soon as the Launching Effect is considered as a perceptual Form with a definite structure, it follows that temporal contiguity must be a factor in the structural organisation, and the question arises as to what part it plays. Clearly we have here another case in which the method of genetic analysis is called for, especially since we have already noticed on various occasions how close the relationship is between the Launching Effect and the continuous movement of a single object, and how easily one may pass from the former to the latter. (See expts. 7–10, pp. 47 seq.) Consequently it is important for us to make a comparison between the effects of a halt, whether long or short, at the point of impact in the case of launching and similar intervals between the movements of a single object.

Here, first of all, is a launching experiment performed with intervals between the movements:

Exp. 29. This is the same as exp. 1 except that we introduced a series of intervals between the arrival of A and the departure of B. The series ranged from 0 to 224 milliseconds in steps 14 milliseconds apart. Ten different intervals were presented in a random order (constant method).

Three subjects performed two series of observations; in one the two objects moved at a speed of 40 cm. per sec.; in the other they moved at a speed of 10 cm. per sec.

the *hierarchy of priority* (to distinguish it from the hierarchy of speeds, which will be considered later). This hierarchy of priority is usually ensured by the presence of objective factors, in particular the temporal priority of the movement of the motor object in relation to the withdrawal of the object struck. This formation of a hierarchy can occasionally arise, however, under the influence of subjective factors, such as the attitude of the observer or the prevalence of the launching Form over the other perceptual Forms.

As the rôle of the objects in the Launching Effect is essentially concerned with the total structure, this rôle can be filled by any objects, irrespective of their colour, their shape, and their size, and also irrespective of their phenomenal nature – irrespective, that is, of whether they are 'real' things or not. Thus, in spite of the absurdity involved, it is possible to produce a perfectly clear causal impression by bringing about the 'launching' of a simple reflection or shadow by a solid object like a wooden ball.

The foregoing remarks have been made in reference to launching-by-striking, but for the most part they apply also to launching-by-expulsion. The principal difference between these two Forms lies in the phase immediately before the departure of the object moved. The essential structural features which have emerged from our examination are: (1) that the two movements are distinct from each other, (2) that one succeeds the other, (3) that they are formed into a hierarchy, and (4) that the movement of the launched object is polarised inversely. These features regularly occur in all cases of launching.

which resulted in the impression of two independent movements being received in one case in ten; (v) the smallest interval which resulted in the impression of two independent movements being received in at least nine cases out of ten.

In view of the variability found in experiments of this kind, we may regard the results as reasonably satisfactory; the figures for the three observers agree fairly well for both sets of speeds, the individual differences, even in extreme cases, never being more than five-hundredths of a second.[2] In addition we found that a number of the individual variations in time-interval for the different stages were not statistically significant. This, however, is a side-issue in relation to our main purpose, which was simply to discover the general trend of the results. From this point of view it seems that the most telling way of setting out the results is to determine the frequency with which the three stages occur at different time-intervals. This has been done in Table IV, where the data provided by all three subjects for both speeds have been pooled. This, I agree, is not a very accurate procedure, but it has the advantage of giving a clear bird's-eye view of the approximate time-intervals which we wanted to know.

TABLE IV

The Launching Effect
Breakdown of stages according to time-interval
(60 *readings at each interval*)

Intervals (ms.)	Direct Launching	Delayed Launching	Two Movements
14	100%	0	0
28	100%	0	0
42	100%	0	0
56	97%	3%	0
70	65%	35%	0
84	32%	68%	0
98	18%	70%	12%
112	5%	68%	27%
126	0	51%	49%
140	0	29%	71%
154	0	2%	98%
168	0	1%	99%
182	0	0	100%

From Table IV, and from Fig. 5, which shows the same results in graphical form, it can be seen that the impression of direct launching

[2] See also the results of exp. 39, in which objects A and B travelled at a speed of 40 and 11 cm. per sec. respectively. These are to be found in Table VIII, 1, p. 114.

The introduction of intervals brings about specific changes in the impressions. These changes are gradual, and the impressions shade imperceptibly into one another. Nevertheless it is possible, from the descriptions given by the observers, to distinguish three different stages with sufficient precision to obtain results for each in quantitative terms. At the first stage we have the familiar Launching Effect. At the second stage, when the interval is greater, the causal impression *is still unmistakable*, but the Launching Effect involves some 'time-lag'. Object B 'sticks' to object A; its departure takes place only after some delay. At the third stage, however, the causal impression disappears, and is replaced by an impression of successive movements of two objects which form a 'whole' – one which is very loosely integrated, there being no internal links.

TABLE III

The Launching Effect

Time-intervals in relation to the different stages

	Direct Launching		Delayed Launching	Two Movements	
Frequencies:	9/10	1/10	7/10	1/10	9/10
1. *Speeds of A and B = 40 cm. per sec.*					
Go.:	84	126	112–140	140	154 ms.
Mi.:	56	112	112	98	154 ms.
Mo.:	56	84	84–112	112	154 ms.
2. *Speeds of A and B = 10 cm. per sec.*					
Go.:	56	84	84–112	112	140 ms.
Mi.:	56	84	84	98	112 ms.
Mo.:	56	112	112	112	168 ms.
Mean:	61	100	105	112	147 ms.

The figures for the time-intervals in these experiments will be found in Table III. This table contains five columns for each subject, and shows, in milliseconds: (i) the largest interval which resulted in an impression of direct launching being received in the nine cases out of ten (nine out of ten so as to minimise the influence of the occasional discrepant case); (ii) the largest interval which resulted in such an impression being received in at least one case in ten; (iii) the intervals which resulted in the impression of delayed launching being dominant – i.e. being received in seven cases out of ten;[1] (iv) the smallest interval

[1] In this experiment, and others of the same type which follow, there was an occasional series in which some subjects did not receive this impression as many as seven times out of ten. When this happened, I have given the interval with which the impression was most frequently associated.

Examination of Table IV shows in addition that the impression of direct launching can be produced, at any rate at times, until the time-interval is about one-tenth of a second.

Delayed launching can be seen when the interval is as little as one-twentieth of a second, and becomes more frequent when it is about a tenth of a second, and is still found in exceptional cases until the interval is about a sixth of a second. It disappears for good when the interval reaches about a fifth of a second.

As can be seen, the distribution of readings for the three stages shows considerable overlap. This accords with the very important fact that there is a continuous gradation in the impressions. In the present case, as in all cases involving perception of form, the differences are not clear-cut. Just as it is possible to have the impression of a shape that is more round or less round and of one that is more square or less square, so it is possible to have the impression of a Launching Effect, or in general, a causal influence, which is more pronounced or less pronounced, more clear or less clear, 'better' or 'poorer'. There are differences in degree, and these correspond to definite stimulus-conditions and to the size of the time-intervals in particular. This is a fact which has constantly been brought home to us during our research, and in the course of this book we shall meet many more examples of the same thing.

It is scarcely necessary to point out that such gradual differences cannot be fitted into any theory which denies that there is a causal impression existing *sui generis*.

The experiment whose results we have just analysed should be compared with the following one, which was carried out in similar conditions except that the two movements were performed by a single object. This experiment has already been mentioned (exp. 3, p. 43), but our purpose then was to study the result from a qualitative point of view, whereas we are concerned now with quantitative data.

Exp. 30. The conditions of exp. 1 were modified in the following way; object B is suppressed; object A moves off, stops in its usual place, then moves off again and travels for a distance of 5 cm.

The length of the halt could be varied from 0 to 224 milliseconds in steps of 14 milliseconds. Ten observations were made by each subject for each interval, and the different intervals were presented in a random order (constant method).

Two series of experiments were carried out, one with a speed of 36 cm. per sec., and one with a speed of 9 cm. per sec. A series of

is produced consistently only when the time-interval is not more than 50 milliseconds. In this connexion it is worth noting that the observers very often mentioned that the Launching Effect was 'better' in cases where there was an interval of 30 to 40 milliseconds at the point of impact than in cases where the second movement followed immediately. This must certainly be attributed to the length of time required for the

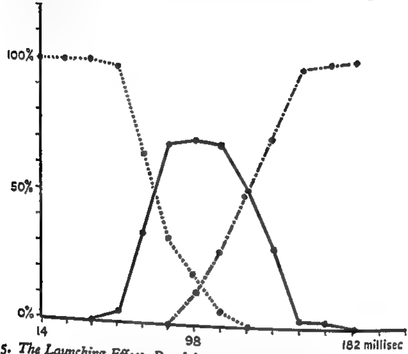

FIG. 5. *The Launching Effect. Breakdown of stages according to time-interval.*
Dotted line—Direct launching
Continuous line—Delayed launching
Dots and dashes—Two movements

'rise of excitation', i.e. the length of time necessary for the observer to receive a fully developed sensory impression of object A after it has halted at the centre. Indeed when the intervals are very short or non-existent, observers often have the impression that the two objects do not meet at all, there being thus neither contact nor impact. This happens all the more often as the speed of the movement increases. Now the greater the speed of the movement, the greater also is the difference between the excitation produced by the object in movement and that produced by the object after it has come to a halt; as a result the time taken by the 'rise' of excitation must necessarily be longer. In our disc experiments, then, and with the degree of illumination which we used, we may reckon with a fair degree of accuracy on the basis of our observed data that the time for the 'rise of excitation' is approximately 30 milliseconds.

Examination of Table IV shows in addition that the impression of direct launching can be produced, at any rate at times, until the time-interval is about one-tenth of a second.

Delayed launching can be seen when the interval is as little as one-twentieth of a second, and becomes more frequent when it is about a tenth of a second, and is still found in exceptional cases until the interval is about a sixth of a second. It disappears for good when the interval reaches about a fifth of a second.

As can be seen, the distribution of readings for the three stages shows considerable overlap. This accords with the very important fact that there is a continuous gradation in the impressions. In the present case, as in all cases involving perception of form, the differences are not clear-cut. Just as it is possible to have the impression of a shape that is more round or less round and of one that is more square or less square, so it is possible to have the impression of a Launching Effect, or in general, a causal influence, which is more pronounced or less pronounced, more clear or less clear, 'better' or 'poorer'. There are differences in degree, and these correspond to definite stimulus-conditions and to the size of the time-intervals in particular. This is a fact which has constantly been brought home to us during our research, and in the course of this book we shall meet many more examples of the same thing.

It is scarcely necessary to point out that such gradual differences cannot be fitted into any theory which denies that there is a causal impression existing *sui generis*.

The experiment whose results we have just analysed should be compared with the following one, which was carried out in similar conditions except that the two movements were performed by a single object. This experiment has already been mentioned (exp. 3, p. 43), but our purpose then was to study the result from a qualitative point of view, whereas we are concerned now with quantitative data.

Exp. 30. The conditions of exp. 1 were modified in the following way; object B is suppressed; object A moves off, stops in its usual place, then moves off again and travels for a distance of 5 cm.

The length of the halt could be varied from 0 to 224 milliseconds in steps of 14 milliseconds. Ten observations were made by each subject for each interval, and the different intervals were presented in a random order (constant method).

Two series of experiments were carried out, one with a speed of 36 cm. per sec., and one with a speed of 9 cm. per sec. A series of

additional observations was made with a speed of 72 cm. per sec. In all three series the object moved at the same speed before and after its halt.

The descriptions given by the observers enable us to confirm the existence of the specific stages mentioned earlier and to mark them off. First there is continuity of the movement, with or without the object being 'caught' on something; secondly there is a discontinuity which is still compatible with the unity of the whole, i.e. the 'movement in two stages'; finally there is the impression of a halt, or definite pause, and together with this the impression of two separate movements. It is an essential feature of the 'movement in two stages' that it is not equivalent to a division into two movements. The unity of the whole in this case is still so strong that it is common to hear subjects spontaneously using expressions which reflect the oddity of the situation; 'a single movement in two stages' is a case in point. It is only on reflection that they realise that strictly speaking the only things that there can be two of are movements. A clear-cut impression of duality, i.e. an impression of two genuinely separate processes, arises only at the third stage.

Table V has been drawn up on the same plan as that adopted for the Launching Effect. It contains (i) the longest halt-time which still results, in nine cases out of ten, in an impression being given of continuous movement (including both uniform movement and movement in which the object becomes 'caught' on something); (ii) the longest halt-time which results, in at least one case in ten, in an impression of continuity; (iii) the longest halt-time which results in an impression of movement in two stages being dominant, i.e. appearing at least seven times out of ten; (iv) the shortest halt-time which results in an impression being given, in at least one case in ten, of a halt and two distinct movements; (v) the shortest halt-time which results in an impression of a halt being given at least nine times out of ten.

No mention has been made of the results obtained when the highest speed (72 cm. per sec.) was used, because in these conditions any attempt to distinguish between the stages was a somewhat uncertain business. In the case of subjects Go. and Mo. the continuity stage was never clearly passed; a halt of 168 milliseconds (the maximum used in this experiment) was insufficient to break the continuity, and there was still the impression of the object becoming 'caught' on something, of an interrupted or zig-zag movement. Similarly in the case of Mi., too, the

stage where there is a duality of movements was never reached, but in this case the impression of the object becoming 'caught' on something continued until the length of the halt was 112 milliseconds (instead of 70 milliseconds as in the case of the other speeds).

TABLE V

Successive movements of a single object
Time-intervals in relation to the different stages

	Continuity		Discontinuity	Halt	
Frequencies:	9/10	1/10	7/10	1/10	9/10
1. *Speed = 36 cm. per sec.*					
Go.:	42	70	70–84	84	112 ms.
Mi.:	42	70	70–112	98	154 ms.
Mo.:	70	112	112–140	140	168 ms.
2. *Speed = 9 cm. per. sec.*					
Go.:	42	56	56–98	84	112 ms.
Mi.:	42	70	56–70	84	112 ms.
Mo.:	70	98	98–112	112	154 ms.
Mean:	51	78	90	100	135 ms.

The results obtained in the case of the two other speeds are fairly similar to each other; indeed the slight differences between them are not large enough to be taken into account.[3] It seems, however, as if the first two stages tend to reach slightly higher intervals when the speed is 36 than when it is 9 cm. per sec.

This fits in with the numerous observations which go to show that there is a stronger tendency towards unity of the whole the higher the speed. This tendency becomes noticeable, however, only when the speeds are very fast.

When we compare the results given here with those obtained from the launching experiments, there is a very clear overall agreement between the time-intervals (in their relationship to the different stages), except that for the present experiments they are shorter (between 10 and 20 milliseconds on the average). It follows that the segregative influence of the halt is a little less strong when only one object is involved than it is in the case of the Launching Effect. This is easy to

[3] See also the results in the similar experiment, 44, in which the successive movements had the speeds of 36 and 11 cm. per sec. respectively. These are to be found in Table X, 1, p. 116.

understand. We find the same tendency if we compare the frequencies for the movements of a single object in Table VI and the corresponding curves (Fig. 6) with Table IV and the curves for the Launching Effect (Fig. 5). The similarity of the results is immediately obvious.

TABLE VI

Successive Movements of a Single Object
Breakdown of stages according to time-interval
(60 *readings at each interval*)

Intervals (ms.)	Continuity	Discontinuity	Halt
14	100%	0	0
28	98%	2%	0
42	95%	5%	0
56	57%	43%	0
70	31%	68%	1%
84	22%	61%	17%
98	9%	66%	25%
112	1%	45%	54%
126	1%	36%	63%
140	1%	23%	76%
154	0	7%	93%
168	0	0	100%
196	0	0	100%

The stages which we distinguished in the launching experiment are clearly parallel (except for a small shift throughout) to those which can be differentiated in the experiments with a single object. Thus (i) the stage of direct launching corresponds to that of continuity of movement; (ii) the stage of delayed launching corresponds to that of movement in two stages; and (iii) the stage when the causal impression disappears corresponds to that of a duality of movements.

The various degrees of unity, viz. complete integration, two stages, and duality of movements, thus appear in both cases and in similar temporal stimulus-conditions. We may therefore claim that the factors for unity which operate in the case of movements of a single object, viz. similarity, good continuation, etc., are also those whose operation determines the different stages in the launching experiments. Here, too, rise to different degrees of unity give rise to impressions of different kinds; *thus to continuity of movement corresponds unity of action, to movement in two stages corresponds delayed launching, and to the duality of movements corresponds the disappearance of the causal impression.*

Thus the Launching Effect occurs only when the temporal conditions ensure that the movements are united in one whole.

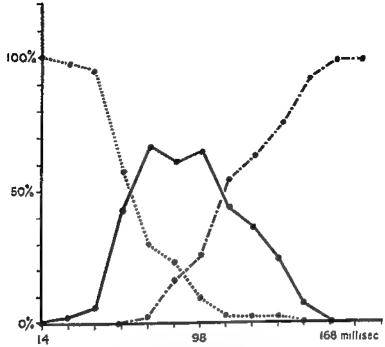

FIG. 6. *Successive movements of a single object. Breakdown of stages according to time-interval*

Dotted line—Continuity
Continuous line—Discontinuity
Dots and dashes—Halt

2. SPATIAL UNITY

Temporal contiguity is not the only thing necessary to ensure the integration in one whole of the two movements involved in the Launching Effect. Indeed, it is easy to show that this effect is obtained only if certain spatial conditions are satisfied also. The purpose of the present section is to study these conditions.

i. *Spatial contiguity*

There is first of all the question of 'action at a distance'. From the following experiment it seems that immediate contact between the objects is not an absolute necessity for the production of the Launching Effect.

The introduction of a gap in the middle does not always destroy the Launching Effect. Thus a distance of 10 mm. at the point of impact when we used a speed of 30 or 40 cm. per sec. has scarcely any effect on the result; often the impression is still that of A dealing a blow which launches B. When the distance is even greater, observer Mi. speaks of 'object A launching B without striking it', and observer Mo. speaks of 'object A launching B with a fairly solid viscous medium as intermediary'.

Once again, however, speed is the all-important factor. When the speed was 25 cm. per sec. and the gap 20 mm., the Launching Effect was almost invariably destroyed, whereas when the speed was 90 cm. per sec. this happened only if the gap was increased to 50 or even 70 mm.; and even larger gaps, to as much as 500 mm., did not necessarily make the causal impression disappear. It seemed to the two observers that object A still had some sort of 'triggering' influence on B's movement.

There is certainly more here phenomenally than a simple temporal co-ordination between the movements; in other words the impression is not like that produced if two objects are made to travel on parallel paths with A stopping 20 or 30 mm. above B.

Anything which favours the integration of the two events in one whole accentuates the Launching Effect. This can be seen from the following experiment, which was carried out by the disc method.

Exp. 32. Exp. 1 is modified here by the addition of coloured lines 70 mm. long and 5 mm. wide along the edges of the slit. This has the effect of making a sort of 'corridor' which begins at a distance of 15 mm. from object A and contains object B.

The movement of object A brings it into the corridor. It stops 30 mm. from B, which immediately begins to move. (The speed is 40 cm. per sec.)

The impression of launching at a distance is quite clear, but it disappears, or at least is considerably weakened, when the corridor is removed.

We can conclude from this that it is certainly possible to produce a causal impression of launching at a distance, and that this depends on the speed. These facts must no doubt be explained in terms of the radius of action, and the first hypothesis that suggests itself is obviously that the impression of launching can be produced only if the distance between the two objects is less than the radius of action. This, however, is only a suggestion, and needs to be tested by further research.

ii. *The relative orientation of the movements*

In all the experiments so far mentioned, the paths of the two movements were in one continuous line. Now, according to what we know about the perception of both static and kinematic Forms, this should be very favourable to the integration of the movements. A difference of orientation, on the other hand, might be expected to act in the direction of segregation and to weaken the causal impression in so far as this impression requires the unification of the movements.

Several experiments were undertaken along these lines, and systematic changes were made in the respective directions of the two movements while their spatial and temporal contiguity was retained.

Exp. 33. The easiest procedure is to alter the Type-experiment by shifting the starting-place of object B in such a way that the path which it travels is parallel to the prolongation of A's path. Object A sets off and takes up position immediately above or below B and in contact with it. At this moment B starts to move in its turn, and follows a route parallel to the prolongation of the route followed by A.

For this experiment the projection method was used, the objects being circles 30 mm. in diameter, projected on a dark background. They moved at about 30 cm. per sec. The observation-distance was from 1·5 to 2·5 m.

In these conditions there is no longer any impact between the objects, and the Launching Effect disappears almost entirely. It is usually replaced by the impression of triggering. This too is a somewhat unstable impression, and the result is often that the two movements appear independent.

In the following experiments the paths travelled by the two objects form an angle, but at the moment of impact object A occupies the same position in relation to B as it did in the Type-experiment. This necessitated certain alterations in our apparatus.

Exp. 34. By means of the projection method the paths can easily be set at right-angles to each other. For this particular experiment two mirrors are fixed, one above the other in front of one of the projectors. Each mirror is inclined to an angle of 45° to a perpendicular axis between them. This gives the image a vertical movement on a screen at the side. The image from the second projector is reflected on to the same screen by a third mirror, and moves horizontally.

In other respects the experimental conditions were the same as those in the previous experiment.

Exp. 35. If the disc method is used, the arrangement for exp. 1 is altered so that the slit is bent instead of being straight, and the two halves form the required angle. The curve drawn on the disc must of course be altered to fit.

It is not possible, however, to go very far along these lines without introducing clearly observable differences in the shape and size of the objects. In practice, the largest possible angle between the two branches of the slit is 105° (compared with 180° in the usual experiments with a straight slit).

The experimental results obtained by using the two different methods are complementary, and there is full agreement between them. *The greater the angle between the paths, the weaker becomes the Launching Effect*, until it disappears completely, or almost so, when the angle is a right-angle. When the angle is 155°, i.e. only 25° off a straight line, there is already considerable weakening of the Launching Effect. The bending of the path clearly breaks up the unity of the whole – a result similar to that produced when a static line is bent. In this case, however, the effect is more pronounced. This is no doubt because the presence of two objects has a segregative influence.

When we consider that we frequently come across similar combinations of movements in ordinary life which are nevertheless looked upon as clear cases of causality, these results seem very peculiar. All billiards-players, for example, and even children playing marbles, know perfectly well that one ball striking another can send it off in a different direction, and even at right angles to the direction travelled by the ball that hit it.

Another curious case in this connexion is that of movements in diametrically opposite directions, particularly those occurring, e.g., when a magnet or something electrically charged attracts another object. The following experiment reproduces a situation of this kind:

Exp. 36. Object A and object B are 7 or 8 cm. apart. A begins to move towards B at a speed of 10 cm. per sec. At a given moment B begins to move in the opposite direction at a very high speed. There is a stroboscopic jump; B rushes up to A, which immediately stops. (For this experiment the disc method was used. The conditions, apart from those mentioned, were the same as for exp. 1.)

Some subjects immediately and spontaneously remarked on the analogy between this experiment and the case of the magnet. In spite of this, no observer ever said that he received the impression of any causal link. The movement of B was not produced nor even triggered off by

the approach of A. It was spontaneous and was merely synchronised with one phase in A's movement. Incidentally, the descriptions given in physics textbooks are usually quite correct from a phenomenal point of view; they imply that the iron filings 'move towards' the magnet, not that they are seen to be *pulled by* the magnet.

This example again calls our attention to the difference between the causal impression directly perceived and a mere causal interpretation. The fact that we know that the magnet exerts a causal influence on the iron filings is not sufficient to produce a causal impression. Indeed, in view of our findings on the influence of the orientation of the movements, it actually seems impossible to produce any causal impression whatever with the combinations of movements found in the magnet example.

While we are on the subject it is worth mentioning that the orientation of the two paths in relation to the total framework, as well as the relative orientation of the movements when they are at an angle to one another, seems to have some influence on the Launching Effect. We did not carry out systematic experiments on this question, but a number of incidental observations seem to show that when one of the paths is horizontal and the other at an angle to it, combinations of conditions in which the movement is made from above downwards in the tilted part favour the Launching Effect more than those in which it is made from below upwards.

iii. *The localisation of the movements in the same plane*

The conditions of the launching experiment were modified on this occasion so that the movements of the two objects should occur in planes set at different distances from the observer. This is more difficult to achieve than might be expected. The outcome in fact seems to be a head-on conflict between two opposing factors, those of integration which are operative in the Launching Effect, and those of segregation which keep the two planes spatially distinct. To produce the required segregation it is necessary to introduce the most favourable conditions for noticing the third dimension.

Exp. 37. The projection method was used here. The images of the objects (circles 10 mm. in diameter) were projected on to two small screens, of 15 by 25 cm., set one in front of the other 15 cm. apart, and in front of a dark background which was considerably farther off.

The screens were so placed that from the observer's point of view the second was partly covered by the first, but was 5 or 6 cm. higher and extended 20 cm. beyond it to the right. In addition, the first screen was brightly lit while the second was in shadow. All this was done to make it easier to distinguish the different planes.

At the beginning of the experiment, object B, projected on the rear screen, was just touching the dividing line between the two screens – or so it appeared to the observer. Object A, projected on the front screen 5 or 6 cm. away from this dividing line, began to move and reached the line at the end of its path. At this point the two retinal images were side by side, as in the Type-experiment; and B in its turn began to move. The two paths were horizontal, and apparently prolongations of each other.

The observer, sitting 1·5 metres from the front screen, had his head fixed in a head-rest, and fixated the point where object B touched the dividing line. Object A moved at a speed of 25 cm. per sec. and object B at 10 cm. per sec. – conditions very favourable for giving rise to the Launching Effect.

The results of the experiment were quite unmistakable. When the observer can see the difference in planes clearly, there is no question of a Launching Effect. Each object moves on the plane to which it belongs (and which is its frame of reference), and there is no impression of approach or of withdrawal of one object in relation to the other; thus the two movements seem absolutely independent.

These at least were the results obtained from *binocular vision* by the three experienced observers, Mi., Mo., and Nu. When monocular vision is used, and especially when a small screen is used, so as to conceal from the observer the arrangement of the screens and their outer edges, the matter is very different. In that case there is only a simple background on the same plane, half of which is lit more brightly than the rest. In these conditions a perfect Launching Effect is produced.

This experiment shows once more that if we bring about a modification of the structural order, in this case by making a distinction between different spatial planes and by placing one object in each plane, the causal impression disappears completely.

It does not seem necessary to devote further time to considering the influence of the spatial properties of the movements, although it is clearly possible to carry out a considerable amount of further research on the subject. The essential point as far as we are concerned is sufficiently shown by the previous experiment. There is a better chance of the Launching Effect appearing, and the impression is a clearer one, if

the paths of the two movements are placed in relation to each other in such a way that the conditions favour the formation of a simple and strong spatial unity.[4]

This conclusion links up with that of the previous section on the question of temporal contiguity, and in general we can say that, *for the production of the causal impression of launching, spatio-temporal conditions are required which particularly favour the integration of the two movements in as complete a unity as possible.*

[4] No special experiments were performed by us to study the influence of spatial conditions on the continuity of the movement of a simple object. Such experiments seemed superfluous in view of all that is known on this subject, and particularly in view of the results obtained by Metzger.

The screens were so placed that from the observer's point of view the second was partly covered by the first, but was 5 or 6 cm. higher and extended 20 cm. beyond it to the right. In addition, the first screen was brightly lit while the second was in shadow. All this was done to make it easier to distinguish the different planes.

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I. THE COMMON SPEED OF THE OBJECTS AND THE CAUSAL IMPRESSION

First of all it is worth pointing out that the causal impression is greatly affected by the speed as such when this is identical for the movements of the two objects. The following experiment serves to illustrate this.

Exp. 38. This is the same as exp. 1, except that the movements of the two objects are given the following speeds: 0·4, 0·7, 1·1, 1·4, 1·8, 2·7, 11, 13, 20, 25, 27, 40, 80, and 110 cm. per sec. The highest speed is thus 275 times as fast as the lowest.

The most perfect impression of launching is given with speeds between 20 and 40 cm. per sec. and even a little higher. In view of the size of the objects, as I pointed out earlier, this is quite a high speed.

When a different range of speeds is used, the impression is less good. This is particularly true when the speeds are very high, e.g. 110 cm. per sec. The causal impression then disappears completely, and is replaced by the Tunnel Effect of expts. 7–10 (pp. 47 seq.). This is doubtless due to the fact that the high speed strengthens the tendency to direct integration of the two phases of movement, and perhaps also to the fact that when the objects change over with such rapidity it is no longer possible to discriminate so precisely at the centre.

At speeds of 10–15 cm. per sec., on the other hand, the impact is slight and lacking in vigour, and the lower the speed the less do we get the character of an impact at all. Instead there is a simple contact, but one which still has the effect of driving B off. When we reach a speed below about 3 cm. per sec., this impression of B being driven off by A also weakens considerably; the movement of B tends to become autonomous and the contact appears to do no more than trigger it off.[1]

The existence of a range of speeds particularly favourable to the Launching Effect is easy to understand, provided we admit the hypothesis, which seems forced upon us, that speed acts as a factor of integration. When it is high, it overcomes the factors of segregation, and the two phases of movement fuse with one another and thus give the impression of a continuous movement; when it is very low, the factors of segregation assert themselves more clearly; when it is intermediate,

[1] To appreciate the results of this experiment it is important not to forget the size of the objects, which is about 5 mm. square, nor the observation-distance, which is 1·50 m. If the objects looked a different size, the results would no doubt be different also. Nevertheless it is probable that we should find a range of similar impressions if appropriate speeds were used.

CHAPTER VII

The Speeds and the Hierarchisation of the Movements

We have already had occasion to use the concept of 'hierarchy', and we have seen that from the beginning of the first phase of the Launching Effect a hierarchy of priority was set up, ensuring the dominance of the motor object. So far, however, we have not taken into account the ratios between the speeds of the movements which are causally linked.

This question is connected with the general problem of the relations which must exist between 'effect' and 'cause'. Is it absolutely necessary that there should be similarity between the two, and how pronounced must this similarity be?

The details given a few pages ago of the spatial conditions of the Launching Effect certainly show that spatially a high degree of similarity is required. There must be identity of plane and similarity of direction. It seems certain, however, in view of all the data which we have collected in this book, that the similarity does not intervene directly, but only in virtue of the effect which it has on the integration of the two movements in a single total unity. That is the reason why we were concerned with this question in the last chapter.

The same problem clearly arises with regard to speed. Is it indispensable for producing the causal impression that the movement of the passive object should after the impact become similar to that of the active one?

The results of exp. 17 (p. 70) do not suggest this. They show that the causal impression can occur when there is no change in the speed of the passive object and even when there is a phenomenal reduction of speed immediately after the impact – in other words, when the difference between the two movements is accentuated rather than diminished. None the less we still need to know what are the most favourable conditions of speed for the Launching Effect, and this is not merely a question of incidental interest; it is of considerable theoretical importance.

stance, when observations are made at a great distance, as in exp. 9 (p. 49).

These points were studied systematically with three experienced subjects who had performed the whole series of experiments; in this case they made ten observations at each interval. The results were also confirmed at different times by a large number of other observers. There is therefore no doubt that a reduction in the speed of the passive object in relation to that of the active one strengthens the causal impression.

By contrast, if the experimental conditions are reversed, i.e. if the speed of B is increased, the results are completely different.

Exp. 40. This is the same as exp. 1, except that object A moves at one of the following speeds: 29, 25, 22, 18, or 15 cm. per sec., while object B moves at a speed of 40 cm. per sec. This makes the ratios of A and B 1:1·4, 1:1·6, 1:1·8, 1:2·2, and 1:2·7. The experiment was performed with the same subjects, and the same intervals were used as before, except that in this case the upper limit was 126 milliseconds, since this proved to be sufficient.

This experiment gave a very curious result; the Launching Effect disappeared completely when the speed of B became noticeably greater than that of A, and was replaced by the impression of triggering.

Another point of interest was that the ratio of speeds most favourable for the causal impression also produced the clearest impact.[5] The impact is more violent when there is a descending ratio of speeds than when the speeds are the same, and when the movement of the second object is faster, instead of the impact there is a simple contact. The last two experiments also reveal the very striking fact that there is no parallelism between the causal impression and the degree of physical force. Instead the impression is rather better and more stable when the efficacy of the 'cause' – as shown in the speed of the projectile – is less! The same holds in the case of the impact. Its character of violence or '*vis viva*' is the more pronounced the slower the second movement in relation to the first, and reaches its maximum when the object struck remains still (or comes to meet the motor object), i.e. when the impact has no perceptible effect, and the causal impression is entirely absent!

These are fresh paradoxes to add to those which we have encountered already. They make it quite clear – and I do not wish to labour the point – that the causal impression is independent of acquired knowledge of the movement of bodies.

[5] The impact is not, of course, a necessary condition for the causal impression, as is shown e.g. by cases of launching-by-expulsion.

we see the establishment of the special equilibrium between the factors of integration and segregation which is characteristic of the Launching Effect.[2]

2. THE RELATIVE SPEEDS AND THE CAUSAL IMPRESSION

The common speed, however, is not the only factor here, and a relative difference between the speeds of the two moving objects proves to be even more important. Such a difference tends to induce a hierarchy in the sense that the faster movement is phenomenally the more important, and is likely to dominate the other. Consequently it is possible to combine the different influences of this factor with the hierarchy of priority which is essential to the Launching Effect. Thus the Launching Effect can be strengthened or weakened according to whether the influence of the hierarchy of speeds operates in the same direction as the hierarchy of priority or in conflict with it.[3] This enables us to study in more detail the part played in the causal impression by hierarchisation.

A series of tests was carried out with this purpose in mind. The first consisted in making the movement of object A faster than that of object B.[4]

Exp. 39. This is the same as exp. 1, except that object A moves at a speed of 40 cm. per sec. and object B at a speed of 11 cm. per sec. (the ratio between the speeds thus being 3·6:1). In addition, intervals of between 0 and 224 milliseconds, in steps of 14 milliseconds, can be introduced between the movements.

There is no doubt at all that the impression is a better one than when the speeds are equal. It seems that the relative speeds used in this experiment, and even to some extent the absolute speeds, provide almost perfect conditions. A ratio of about 4:1 seems to be required for a good impression. If we increase the ratio to 10:1, this tends to segregate the movements, as will be seen later.

This is not a question of subjective assessment. Objective indications point to the same conclusion. In particular the Launching Effect proves much more resistant to changes in observation-conditions in this case than when the speeds are equal. It is less prone to disappear, for in-

[2] See Chapter VIII.

[3] For a discussion of the hierarchy of priority, see p. 65.

[4] These experiments, in which the *successive movements*, of A before the impact and B after it, were at different speeds, should not be confused with the experiments on Launching-in-flight (pp. 69 seq.), in which different speeds were given to the *simultaneous movements* of A and B before and after the impact.

From this table it will be seen that the triggering impression began to appear for all three subjects when the ratio was 1 : 1·8, and became the most usual impression when the ratio was 1 : 2·7, while the launching impression remained the normal one for the lower ratios of 1 : 1·4 and 1 : 1·6. When the ratio was 1 : 2·2 the conditions were ambiguous, and the two categories of impressions were represented on the average more or less equally.

From these results it might be thought that a ratio of 1:3 would be sufficient to bring about the complete disappearance of the Launching Effect. This, however, is not quite accurate. We did some control experiments with twenty-one new observers, making them compare their impressions (i) when the ratio of speeds was 3·7 : 1 and (ii) when it was 1 : 3·7. Half the observers began with the first combination and the other half with the second.

In the case of a descending ratio of speeds, they all said that they had impressions of launching. When there was an ascending ratio of speeds, however, launching was still reported in twelve out of the twenty-one cases (57%), while in eight cases (38%) the observers definitely said that there was triggering. One case was doubtful.[7]

There was thus full confirmation that the two impressions are different, but the ratio of speeds necessary to ensure a general substitution of the Triggering Effect for the Launching Effect is higher than one might have expected; it needs to be about 1:5 or 1:6.

This difference between the results obtained by experienced subjects and those obtained by new subjects is an interesting one; the latter mention Launching Effects when the former have no such impression. This indeed is something which we have found to happen frequently during our research. It seems that practice in these experiments makes experienced observers more critical, and the category of launching is very much more restricted in their case. This indeed makes their observations all the more valuable.[8]

[7] There are undoubtedly marked individual differences on this point. It is even possible that some people get an impression of triggering when the speeds are equal. We have met occasional cases of this, although it has never happened when there was a descending ratio. Moreover a difference in the *apparent* speeds may have this result also. Here too there seem quite often to be considerable individual differences, and it also seems that the speed of the second movement is systematically overestimated.

[8] In the case represented in our experiment, it is interesting to note that, according to the laws of mechanics, if the bodies are perfectly elastic, the speed of the body struck can never be more than double that of the body which

They also show that the phenomenal character of 'force' and the causal impression are not necessarily bound up together and that the former must be carefully distinguished from the idea of force in mechanics. It belongs rather to the group of impressions which vary in intensity, and indeed this is the way in which the word is used in ordinary speech.

The substitution of the Triggering Effect for the Launching Effect in exp. 40 is in direct relationship to the increase of the ratio between the speeds. This is shown by the frequency with which observers assign their impressions to either category, in relation to the combinations of speeds used in each case. In order to show this point clearly, we have taken into account all cases, at every interval from 0 to 70 milliseconds, in which the observers spoke of *direct* triggering or launching, i.e. without any delay or halt.[6] From these figures we have calculated the proportions of Launching and Triggering Effects for each ratio of speeds throughout the whole series. The results will be found in Table VII.

TABLE VII

Frequency of launching and triggering impressions for different ratios of speeds

Speed of A (in cm. per sec.)	29	25	22	18	15
Speed of B (in cm. per sec.)	40	40	40	40	40
Ratio of Speeds	1:1·4	1:1·6	1:1·8	1:2·2	1:2·7
Subject Go.:					
Number of Cases:	*41*	*43*	*32*	*36*	*38*
Launching:	100%	100%	97%	67%	2%
Triggering:	0	0	3%	33%	98%
Subject Mi.:					
Number of cases:	*40*	*38*	*36*	*42*	*49*
Launching:	100%	100%	68%	44%	2%
Triggering:	0	0	32%	56%	98%
Subject Mo.:					
Number of cases:	*34*	*36*	*29*	*28*	*34*
Launching:	100%	100%	69%	55%	13%
Triggering:	0	0	31%	45%	87%
Means:					
Number of Cases:	*115*	*117*	*97*	*107*	*123*
Launching:	100%	100%	78%	55%	6%
Triggering:	0	0	22%	45%	94%

[6] These are in effect the only cases which one is justified in comparing, since, as will be seen later, it is not as easy to distinguish clear stages in the Triggering Effect as it is in the Launching Effect.

The results were identical with those in the previous experiment.

Finally, in a third experiment, the movement of object B in the first combination was at the same absolute speed as that of object A in the second.

Exp. 43. The general conditions were the same as those in the experiment above. The combinations of speeds were as follows:

Speed of object A	*Speed of object B*	*Ratio of A : B*
52 cm. per sec.	21 cm. per sec.	2·47 : 1
20 cm. per sec.	7·7 cm. per sec.	2·6 : 1

There was perfect launching in both cases.

Thus, within the limits and framework of these experiments, the movement of object B, whatever its absolute speed, can appear to be either produced or triggered off according to whether the movement of object A is faster or slower than its own. To sum up, it is the *ratio between the speeds* which determines in the last resort which of the two it is.

3. THE RELATIVE SPEEDS AND INTEGRATION

Granted that the ratio between the speeds has some influence on the appearance of the causal impression, an important problem still remains to be solved if we are to elucidate the question of hierarchisation completely. Does the ratio between the speeds directly influence the characters of dominance and dependence or does it rather affect the degree of integration of the whole?

It was to clarify this point that we introduced variable intervals between the movements of the two objects in expts. 39 and 40. It seems obvious that if the ratio between the speeds affects integration, this will necessarily be shown by a shift in the different stages. For instance, if an ascending ratio tended to weaken the unity of the whole, we might expect to find that the stage of delayed launching and that of two movements occurred when the intervals were shorter than in the case of a descending ratio.

In Tables VIII, 1 and IX, 1 will be found the figures for the intervals for each stage in respect of exp. 39, where there is a descending ratio of speeds. It will be seen that in the case of the two subjects Go. and Mo. the figures are practically identical with those obtained when the speeds were equal (see Table III, p. 92). In the case of subject Mi., on the other hand, they are noticeably higher in the present experiment, which seems to indicate a greater integrating influence of the descending

Up to now I have constantly spoken of the *ratio* of the speeds. The question arises, however, whether it is the ratio as such which effects the impression rather than the absolute speed. In exp. 40 the speed of object B was in fact very fast – 40 cm. per sec. – and we had therefore to consider the possibility that the characters of dependence and dominance were bound up with the absolute speeds. This seemed unlikely *a priori*, but it was desirable to find out for certain. We therefore performed the following series of experiments.

Exp. 41. This is the same as exp. 1, but with the following combinations of speeds:

Speed of object A	*Speed of object B*	*Ratio of A:B*
79 cm. per sec.	21·6 cm. per sec.	3·7:1
6 cm. per sec.	21 cm. per sec.	1:3·5
40 cm. per sec.	18 cm. per sec.	2·2:1
7·7 cm. per sec.	18 cm. per sec.	1:2·3
40 cm. per sec.	11 cm. per sec.	3·7:1
3·1 cm. per sec.	11 cm. per sec.	1:3·5

There were three sets of combinations of speeds in this experiment, in each of which object B moved *at the same speed*; but in one case its movement was preceded by a faster movement on the part of object A, in the other by a slower movement. Those who took part were all experienced observers, and they consistently received an impression of launching when the faster movement came first and of triggering when the slower movement came first.

Another experiment was performed by means of the projection apparatus, since it was thus possible to use higher speeds.

Exp. 42. The objects were circles of light, 35 mm. in diameter, on a dark background. A's path was between 6 and 12 cm. long, B's about 50 cm. The observation distance was 2·50 m.

The following combinations were used:

Speed of object A	*Speed of object B*	*Ratio of A:B*
130 cm. per sec.	52 cm. per sec.	2·5:1
19·4 cm. per sec.	48 cm. per sec.	1:2·27

does the striking, however great the difference in mass between the bodies concerned.

This limit in fact agrees very well with that of the launching impression as found by our experienced observers, whose results are probably the most clear-cut. Here as in many other perceptual fields there seems to be a curious agreement between the operation of the laws of perception and that of the laws governing the physical world.

3. *Speed of A = 15 cm. per sec. Speed of B = 40 cm. per sec. Ratio = 1:2·7*

	Direct Triggering		Discontinuity	Halt	
Frequencies:	9/10	1/10	7/10	1/10	9/10
Go.:	42	70	70–84	84	112 ms.
Mi.:	70	84	84–98	98	? ms.
Mo.:	28	70	70–98	98	126 ms.
Means:	47	75	84	93	? ms.

It is worth noting that the figures obtained for the two speed ratios just considered are obviously lower than those in exp. 39 (where there was a descending ratio), and even lower for the most part than those obtained when the speeds were equal (Table III). *This occurs throughout, and in the case of all three subjects.* It therefore seems to be established that an ascending ratio has a segregative influence.

TABLE IX

The Launching and Triggering Effects
Breakdown of stages according to time-interval
(30 *readings at each interval*)

1. *Speed of A = 40 cm. per sec. Speed of B = 11 cm. per sec. Ratio = 3·6:1.*

Intervals (ms.)	Direct Launching	Delayed Launching	Two Movements
14	100%	0	0
28	100%	0	0
42	100%	0	0
56	100%	0	0
70	83%	17%	0
84	58%	42%	0
98	50%	50%	0
112	17%	75%	8%
126	3%	77%	20%
140	0	65%	35%
154	0	40%	60%
168	0	23%	77%
196	0	10%	90%
224	0	3%	97%

2. *Speed of A = 29 cm. per sec. Speed of B = 40 cm. per sec. Ratio = 1:1·4.*

Intervals (ms.)	Direct Launching	Delayed Launching	Two Movements
14	100%	0	0
28	100%	0	0
42	97%	3%	0
56	62%	38%	0
70	22%	78%	0
84	0	92%	8%
98	0	75%	25%
112	0	27%	73%
126	0	3%	97%

ratio. We cannot, however, attach much importance to this finding since the discrepancy observed could be simply due to some incidental occurrence.

The results obtained from exp. 40, where there is an ascending ratio, are different; they are set out in Table VIII, 2 and 3 and Table IX, 2 and 3. Under 2 will be found the results when the ratio between the speeds is 1 : 1·4, which still gives an impression of launching, as was pointed out earlier, and under 3 the results when the ratio was 1 : 2·7, which generally gives an impression of triggering.

It should be noted, however, that the stages take a somewhat different form in the case of the Triggering Effect. Since object B's movement seems to some extent autonomous whatever the interval, it is less easy to distinguish between the stages than in the case of the Launching Effect, and we had to modify our criteria accordingly. We considered as the first stage that in which the triggering occurred directly – 'as though somebody pressed a button', as one observer put it. This stage corresponds to direct launching. The second stage comprised those cases in which there was an impression of discontinuity of some kind. This stage corresponds to delayed launching. Lastly, at the third stage, there was a pause, i.e. a halt of appreciable duration. This corresponds to the 'two movements' stage. The limits are obviously less clearly defined than those in the Launching Effect, but in general they seem to represent the different stages fairly well.

TABLE VIII

The Launching and Triggering Effects
Time-intervals in relation to the different stages

1. *Speed of A* = 40 *cm. per sec. Speed of B* = 11 *cm. per sec. Ratio* = 3·6:1.

	Direct Launching		Delayed Launching	Two Movements	
Frequencies:	9/10	1/10	7/10	1/10	9/10
Go.:	70	112	112–140	140	168 ms.
Mi.:	98	126	126–154	154	224 ms.
Mo.:	56	84	84–112	112	154 ms.
Means:	75	107	121	135	182 ms.

2. *Speed of A* = 29 *cm. per sec. Speed of B* = 40 *cm. per sec. Ratio* = 1:1·4.

Frequencies:	9/10	1/10	7/10	1/10	9/10
Go.:	42	70	70–98	112	126 ms.
Mi.:	42	70	70–84	84	112 ms.
Mo.:	42	70	70–98	98	126 ms.
Means:	42	70	82	98	121 ms.

2. *Successive speeds* = 11 *cm. per sec. and* 36 *cm. per sec. Ratio* = 1:3·3.

Go.:	14	42	42–56	70	84 ms.
Mi.:	42	98	70–112	84	224 ms.
Mo.:	70	112	112–126	126	154 ms.
Means:	42	84	86	93	154 ms.

When the halt-times are very short, there is no break in continuity. The change in speed takes place quite smoothly, and the impression is one of progressive deceleration or acceleration, stretching over a large amount of the path, rather than of any break; and the smaller the difference in speed, the further this stretch seems to extend. When the intervals are longer, there comes a time when the break becomes abrupt

TABLE XI

Successive movements of a single object
Breakdown of stages according to time-interval
(30 *readings at each interval*)

Intervals (ms.)	Continuity	Discontinuity	Halt
1. *Successive speeds* = 36 *cm. per sec. and* 11 *cm. per sec. Ratio* = 3·3:1.			
14	100%	0	0
28	100%	0	0
42	100%	0	0
56	97%	3%	0
70	87%	13%	0
84	70%	30%	[illegible]
98	53%	49%	0
112	20%	73%	7%
126	10%	71%	13%
140	0	73%	27%
154	0	33%	67%
168	0	10%	90%
196	0	0	100%
224	0	0	100%
2. *Successive speeds* = 11 *cm. per sec. and* 36 *cm. per sec. Ratio* = 1:3·3.			
14	100%	0	0
28	80%	20%	0
42	63%	37%	0
56	53%	47%	0
70	43%	43%	14%
84	30%	33%	37%
98	13%	50%	37%
112	0	60%	40%
126	0	37%	63%
140	0	30%	70%
154	0	13%	87%
168	0	7%	93%
196	0	10%	90%
224	0	0	100%

3. *Speed of A = 15 cm. per sec. Speed of B = 40 cm. per sec. Ratio = 1:2·7.*

Intervals (ms.)	Direct Triggering	Discontinuity	Halt
14	88%	0	0 [9]
28	92%	0	0
42	92%	8%	0
56	66%	32%	0
70	40%	60%	0
84	6%	87%	7%
98	0	72%	28%
112	0	27%	73%
126	0	10%	90%

Nevertheless this conclusion needed confirmation. In particular it was necessary to find out whether this was a phenomenon peculiar to experiments like those just described, or whether it was also to be found in the case of movements of a single object. (This is a further application of the method of genetic analysis.) If the latter were to turn out to be the case, the segregative influence of an ascending ratio of speeds would not be something confined to experiences of causality, but would exemplify some more general principle.

The next experiment is a first attempt to discover the answer to this question.

Exp. 44. This is the same as exp. 1, except that object B has been removed. Object A sets off, stops at its usual place, then moves off again and travels 5 cm.

The halt-time could be varied from 0 to 224 milliseconds, in steps of 14 milliseconds.

In the first series of experiments, the speed of the movement before the halt was 36 cm. per sec. and that of the movement afterwards was 11 cm. per sec. In the second series it was the other way round, 11 cm. per sec. before the halt and 36 cm. per sec. after it.

The two series were conducted in parallel during the same few days.

TABLE X

Successive movements of a single object
Time-intervals in relation to the different stages

		Continuity	Discontinuity	Halt	
Frequencies:	9/10	1/10	7/10	1/10	9/10
1. *Successive speeds = 36 cm. per sec. and 11 cm. per sec. Ratio = 3·3:1.*					
Go.:	70	112	112–126	126	196 ms.
Mi.:	56	112	98–140	112	168 ms.
Mo.:	98	140	126–140	140	168 ms.
Means:	75	121	124	126	177 ms.

[9] Where the figures do not add up to 100, this means that in the remaining cases a launching impression was received.

TABLE XIII

Successive movements of a single object
Breakdown of stages according to time-interval
(20 readings at each interval)

Intervals (ms.)	Continuity	Discontinuity
1. *Successive speeds* = 36 *cm. per sec. and* 7·2 *cm. per sec. Ratio* = 5:1.		
14	100%	0
28	100%	0
42	100%	0
56	65%	35%
70	35%	65%
84	10%	90%
98	0	100%
112	0	100%
2. *Successive speeds* = 7·2 *cm. per sec. and* 36 *cm. per sec. Ratio* = 1:5.		
14	100%	0
28	95%	5%
42	75%	25%
56	10%	90%
70	0	100%
84	0	100%

It is interesting to compare the results of the two last experiments. The higher ratio of speeds (5 : 1) clearly has a more marked segregative influence than the other (3·3 : 1), both in the case of ascending ratios and in the case of descending ratios. Thus a very large difference in speed probably favours segregation. That is why a ratio of 10 : 1 between the first and second movements is not very favourable to the Launching Effect, as was pointed out earlier. It follows that, if the causal impression is to be produced, there must be some degree of similarity between the movements as regards speed, as well as in other respects; but here again the fundamental reason for this requirement seems to be the part played by similarity as an integrating factor in the structural organisation of what is perceived.

4. THE HIERARCHY OF THE MOVEMENTS AND THE LAUNCHING AND TRIGGERING EFFECTS

It is possible that the segregative influence which we have just described may play some part in giving rise to triggering instead of launching in those cases where there is an ascending ratio of speeds, and that it is this segregative influence which favours the autonomous character of B's movement.

and when once again there is discontinuity, although without the impression of an actual halt; this corresponds to what I called earlier 'movement in two stages'. Lastly, when the intervals are still greater, the two movements are clearly separated, and there is a pause. These are the stages whose limits we tried to fix by means of the present experiments.

The requisite figures are set out in Tables X and XI. From these tables it can be seen that in the case of all three subjects the time-intervals in relation to the different stages were smaller in the case of an ascending ratio than in the case of a descending ratio.[10] This is in complete agreement with our earlier conclusions. Here too, therefore, an ascending ratio tends to have a segregative influence.

To check this, another experiment was performed, in which we introduced an even greater difference between the speeds, viz. ratios of 5 : 1 and 1 : 5.

Exp. 45. This experiment was similar to the previous one, except that in the first series the speed of the movement before the halt was 36 cm. per sec., and that of the movement after the halt was 7·2 cm. per sec. In the second series it was the other way round, 7·2 cm. per sec. before the halt, and 36 cm. per sec. after it.

We restricted ourselves here to fixing the limit between the stages of continuity and discontinuity, as this is of most interest. The results are given in Tables XII and XIII. These experiments were carried out with the two subjects Mi. and Nu.; they confirmed our earlier conclusion that the impression of continuity disappears sooner, for both observers, when there is an ascending ratio than when there is a descending ratio.

TABLE XII

Successive movements of a single object
Time-intervals in relation to the different stages

Frequencies:	Continuity 9/10	1/10	Discontinuity 7/10
1. *Successive speeds = 36 cm. per sec. and 7·2 cm. per. sec. Ratio = 5:1.*			
Mi.:	42	70	70 ms.
Nu.:	42	84	84 ms.
Means:	42	77	77 ms.
2. *Successive speeds = 7·2 cm. per sec. and 36 cm. per sec. Ratio = 1:5.*			
Mi.:	42	56	56 ms.
Nu.:	28	42	56 ms.
Means:	35	49	56 ms.

[10] With one exception, viz. Mi.'s results for the last stage.

produce either phenomenon at will, and to pass progressively from one to the other, as none of our other experiments do.

The Triggering Effect, like the Launching Effect, can vary. In some conditions it is purer and clearer than in others. It can come very close to launching proper (since there are cases where observers hesitate to classify one way or the other), and it can come very close to simple temporal co-ordination, without an internal link between the events. (In this last case, too, observers are sometimes at a loss to decide whether there was a triggering or merely the coupling of two quite independent events.) If, however, we compare the standard cases of launching and triggering, we can discover resemblances and differences between them which are very instructive.

In both cases there is clearly *inversion of polarity* in the movement of object B. This inversion, however, has very different aspects in the two cases. In the Launching Effect, as we know, polarisation takes the form of an impression that the blow dealt by A *drives* B *away*. When there is triggering, on the other hand, B *runs away* from A; and the greater the difference between the speeds, the closer this impression of running away comes to the simple Withdrawal Effect. Again we cannot mark the limits of the radius of action as clearly in the Triggering Effect as we do in the Launching Effect. It is no longer the distance to which the blow dealt by A drives away B, but rather the distance for which B does nothing else but leave A (see Chapter IV, pp. 65 seq.).

This links up with the fact that the movement of B seems to be *autonomous* in the Triggering Effect; it is not *produced* by the coming into contact of the objects, but merely originates from it. The observers are quite explicit on this point. While in the case of launching they tend to say such things as 'A drives away B', 'A launches B', and so on, the expressions used to describe triggerings are very varied, and stress both the autonomous character of B's movement and its dependence on A. Some very amusing descriptions are given: 'It is as if A's approach frightened B, and B ran away', 'It is as if A in touching B induced an electric current which set B going', 'The arrival of A by the side of B acts as a sort of signal for B to go', 'It is as if A touched off a mechanism inside B and thus set it going', and so on. Also this experiment often produces a comical effect and makes the observers laugh. This never happens with the Launching Effect. The reason is probably the disproportion between the 'antecedent' and the 'consequent'. Whether this is so or not, the movement of object B is its own and belongs

This influence, however, is apparently not the only one involved, and certainly does not fully account for the phenomenal difference between the two 'effects', as is shown by the following considerations.

In the first place, it is a general principle that if we diminish the degree of integration in the launching experiments, this is not sufficient to produce the impression of triggering. This can be seen particularly clearly from those launching experiments in which intervals are introduced at the point of impact. As we have seen, the Triggering Effect does not figure among the different stages which we found it helpful to distinguish in this group of experiments.

In the second place, the Triggering Effect, like the Launching Effect, comprises an internal linking up of the two events and thus an integration in one whole. Indeed to produce the phenomenon at all it is necessary to provide experimental conditions of a kind to ensure a high degree of integration. Thus in exp. 40 (Tables VIII, 3, p. 115 and IX, 3, p. 116), the impression of triggering occurs only when there are extremely short intervals – short enough not to interfere with the unity of the whole process.

Thirdly and lastly, exp. 40 constitutes a special case which seems very instructive. The impression of launching was the universal result when there was an ascending ratio of speeds of 1 : 1·4 (Table VII, p. 110), while the impression of triggering became the rule, with the same subjects, when there was a ratio of 1 : 2·7. Now a comparison between the limits of the different stages shows that they are similar for both these ratios (1 : 1·4 and 1 : 2·7); the means are very nearly the same (see Tables VIII and IX, 2 and 3). In so far, then, as the figures for the limits of the stages provide indications of the degree of integration, it is clear that this was practically the same in the two cases, and that therefore the distinction between the Launching and Triggering Effects is largely independent of the degree of segregation.

We may therefore conclude that the ratio of the speeds has a *direct* influence on the character of the causal impression, which brings us back once more to the concepts of phenomenal hierarchy, dominance, and dependence. In order to make these concepts more precise, we need to examine more closely than we have done so far the respective characters of the Launching Effect and the Triggering Effect.

Our experiments on the influence of the ratios between the speeds are particularly useful in our study of this problem; in fact they enable us to

resolution of the conflict, seen in the Triggering Effect, is really a compromise, reconciling opposing tendencies. *The movement of object B is independent of that of object A in that B performs it, but is still dependent in that A originates it.* The dependence is thus reduced to its narrowest limit; instead of extending over the whole length of the radius of action, it is limited to the moment of the departure of object B. In other words, the movement of object A is only a prelude to the important event; it serves simply to bring about the contact which is responsible for setting object B in motion.

We can see now how and why an ascending ratio of speeds exerts a direct influence on the structural organisation of the impression, and leads to the substitution of the Triggering Effect for the Launching Effect.

to it, and to this extent is largely independent of the movement of object A.

On the other hand it is equally clear that this movement is not *spontaneous* like that of an isolated motionless object which suddenly begins to move. As the observers point out, it is obvious that the arrival of A 'does something' to bring about the departure of B. It is here, no doubt, that the specific character of this impression is to be found – a character which observers try to convey by using comparisons with known cases where they have had similar impressions. In short what matters here is the *departure* of B; as soon as the contact has taken place, and as a result of it, B seems to move of its own accord.[11]

Impressions closely related to those which I have just described in connexion with launching and triggering can also occur in the case of a single object, if, as in exp. 44, we bring about an abrupt change in the speed of its movement. In this case too the phenomenal character of a reduction in speed is very different from that of an increase. In the first case we receive the impression of something which *comes to an end* or *is extinguished*; the slower phase is like a sequel, a left-over piece of what went before, which was the important event. When the speed increases, on the other hand, as in the case of triggering, the first phase of the movement appears rather as a *preparation* or *curtain-raiser*, and it is only after this that the moving object really gets going. The movement at this point is invested with a very clear character of activity which corresponds to the autonomy of the movement in the Triggering Effect.

These descriptions of the Launching and Triggering Effects enable us to set out in clear terms the fundamental difference in structural organisation between the two forms of causal impression.

In the Launching Effect, when the two movements have the same speed, the movement of A dominates that of B because of its temporal priority. In cases where the speeds are different, and there is a descending ratio, it does so still more because of its higher speed.

In the Triggering Effect, as it appears in the experiments in this chapter, since the speed of B is appreciably higher than that of A, it is B's movement which ought to dominate that of A. A conflict thus arises between the hierarchy of speeds and the hierarchy of priority, and the

[11] It should be emphasised that the terms 'autonomous' and 'spontaneous' used in this book refer to phenomenal characters which are respectively (i) the impression that the movement *belongs* to the object which performs it (autonomy), and (ii) the impression that the movement of an object is not *brought about* by the action of another object (spontaneity).

Spatial conditions

The most favourable conditions for the Launching Effect are obtained when the paths of the two movements are contiguous, one being a continuation of the other, and are situated in the same plane.

The Launching Effect can occur, however, when there is a certain distance between the position where the motor object stops and the position where the passive object starts. It is a case of 'impact at a distance'. The distance is a function of the speed.

On the other hand, any horizontal shift in the path of the motor object in relation to that of the object struck (so as to bring the motor object above or below the other at the moment when they come into contact) makes the Launching Effect disappear. Similarly an angular shift, even though arranged so as to give the two objects their normal positions at the point of impact, weakens the Launching Effect considerably. This is practically destroyed when the angle formed by the paths reaches 90°, and is still more affected when the two movements are in opposite directions. It thus seems impossible to produce a visual causal impression of one object being attracted by another.

Lastly, if the movements are localised in different planes in space, the causal impression is destroyed, provided that the relative position of the planes in the third dimension is clearly seen. Each of the two movements is then referred to the plane in which it takes place and is seen as entirely unconnected with the other.

In cases when the spatio-temporal conditions are not fully realised, the Triggering Effect frequently occurs instead of the Launching Effect.

In a general way, then, the spatio-temporal conditions required for the appearance of the Launching Effect must be such as to ensure as complete an integration as possible of the two movements in one whole.

Kinematic conditions

When the two objects move at the same speed, it is clear that their common speed also acts as a factor of integration, and that it does so the more effectively the greater the speed. When the speed is high, it overcomes the factors making for segregation, and the two movements then unite directly in such a way as to form a single movement (Tunnel Effect). By contrast, when the speed is very low the factors of segregation ensure the autonomy of the second movement. Finally, when the speed is moderate, a certain equilibrium is established between its integrating action and the factors of segregation – an equilibrium which

SUMMARY NO. 2

Résumé of Chapters VI and VII

The experiments outlined in Summary No. 1 have shown the importance of the segregative factors which bring about a distinction between the two movements involved in the Launching Effect.

In contrast those which have been mentioned in the last two chapters illustrate the importance of a series of integrative factors, which tend to link the movements in one whole. These factors are related to certain specific spatial, temporal, and kinematic conditions.

Temporal conditions

It is essential to the production of the Launching Effect that the second movement should succeed the first rapidly. In order to determine the exact relevance of this fact, we applied the method of genetic analysis. Our procedure was to introduce different time-intervals at the point of impact in the launching experiments; we then compared the results with those obtained when similar intervals were introduced between two successive movements of one and the same object, the second movement being a continuation of the first.

In both cases a series of phenomenal modifications can be observed, which are related to the length of the halt-time. As a result we can make a distinction between a number of characteristic stages.

(*a*) In the case of the Launching Effect, we can distinguish launching, delayed launching, and the stage when the Launching Effect is suppressed and is replaced by an impression of mere succession of movements of two different objects.

(*b*) In the case of movement of a single object, we can distinguish continuous movement (in some cases of which the object becomes 'caught' on something), movement in two stages, and the stage at which there are two successive movements.

An examination of the temporal limits of the different stages shows a clear correspondence between (*a*) and (*b*). The impression of launching is maintained as long as the intervals are compatible with the unity of movement of a single object, but disappears when the intervals are long enough to break this unity.

important event, conflicts with the hierarchy of priority which tends to give the advantage to the earlier event, and the resolution is given in the form of a compromise achieved in the Triggering Effect. The productive character of the Launching Effect is blurred, and is reduced to a character of simple dependence. Thus the performance of the second movement is no longer linked throughout its course with the blow which started it; the movement becomes *autonomous as it continues*, while still remaining *dependent for its origin* on the fact that the two objects came into contact. This is precisely what characterises the Triggering Effect and differentiates it from the Launching Effect. Apart from this it presents obvious similarities of structure to the Launching Effect, both from the point of view of overall integration and in the fact that the second movement is inversely polarised.

When we compare the data presented in the two sections devoted to the study of the Launching Effect, we find that the conditions in which it occurs are apparently contradictory. Some of them operate towards maintaining a differentiation, even a clear separation, between the two movements; the others, in contrast, particularly the requirements of a certain degree of similarity between the spatio-temporal and kinematic properties of the two movements, tend to bring about a fusion of them in a single continuous movement. There is every reason to believe from the results of our experiments that this is the principal reason why a similarity between 'effect' and 'cause' appears indispensable to the production of the causal impression.

When I discuss the general theory underlying the perception of causality (Chapters VIII, IX, and XIV), I shall try to show how this theory allows for a reconciliation of the opposing tendencies whose combined action leads to a causal impression.

is a special characteristic of the Launching Effect, as we shall see later. There must therefore be a critical range of speeds to which the Launching Effect is restricted.

If there is a considerable difference between the speeds of the two objects, this exerts a segregative influence on the movements; the same is true of smaller differences in cases when the second movement is the more rapid of the two. If on the other hand the first movement is faster and there is a moderate difference between them, there is perhaps a slight strengthening of the tendency towards integration, resulting from the overall conditions of the experiment. These phenomena are similar to those which can be observed when there is an abrupt change of speed during the movement of a single object; once again, general laws relating to the perception of movement are applicable here.

The difference between the speeds not only affects the degree of integration of the movements, but also makes more radical changes in the structural organisation of what is perceived. Indeed it becomes a factor in hierarchisation, and can combine its action with that of the hierarchy of priority, which we considered in Summary No. 1. The result may be a considerable modification of the causal impression. It is not in fact the existence of a difference between the speeds nor their absolute value which is important, but rather the ratio between them.

When this ratio is a descending one, i.e. when the movement of the motor object is more rapid than that of the object struck, the dominance of the first movement over the second is emphasised, because the hierarchy of speeds acts in the same direction as the hierarchy of priority. In these cases the Launching Effect is noticeably more pronounced than in the case where the speeds are equal; at least this is so provided that the difference is not so great as to bring about the segregation of the movements. If other conditions remain the same, the causal impression thus becomes better according to the degree of dominance of the first movement over the second. This is paradoxical, since the causal impression is strengthened even though the efficacy of the 'cause' – an efficacy which should logically express itself in the speed of movement of the 'passive' object – is actually diminished!

In the case of an ascending ratio of speeds, i.e. when the second movement is the faster, the situation is reversed. The *Launching Effect disappears and is replaced by the Triggering Effect.* The hierarchy of speeds, according to which the second movement ought to be the more

displaces B! This is a startling thing to say and seems to run counter both to reason and to ordinary observation. The phrase really implies two propositions, one suggesting the continuity of the movement and the other the fact that it belongs to object A. Now both seem quite untenable; for in the first place the impact clearly marks the end of the movement of object A and the beginning of that of object B, and in the second place it seems inconceivable that the movement of object B should belong not to B, which is moving at the time, but rather to A which has stopped.

We find ourselves with a complete paradox. Yet I think that these difficulties are specious rather than real; the second proposition is nearer the truth than it appears. In fact it is precisely here that the crux of the matter is to be found.

We must ask ourselves, first of all, to what extent and in what sense the movement of the motor object must be considered to be really finished or completed phenomenally at the moment when this object stops.

That we are concerned in the Launching Effect with two distinct events is unquestionable. It appears so to all conscientious observers, and this obvious truth is confirmed by the fact that, as we have seen already, there is a qualitative difference between the movements as a result of their different polarisation.

It is no less clear, however, that these events are not simply juxtaposed; they form an ensemble, a whole, whose character is clearly indicated in the term 'impact-which-launches'. In view of the regularity with which such expressions occur, and the standards of precision of those who use them, it is hard to believe that this phrase is inadequate; the only alternative is to assume that there is a *continuity* between the impact-event and the pushing-away event.

Moreover, it is not only in the Launching Effect that a situation of this kind is found. We mentioned something similar in certain cases of movement of a single object, where what we see is a 'movement in two stages' – an expression which is logically absurd, but which none the less implies that there is both a continuity and a duality at the very core of one and the same kinematic phenomenon.

Other cases, however, are still more interesting from our point of view, the many in which we witness a phenomenal *metamorphosis*.[1]

[1] I use the term 'metamorphosis' rather than 'transformation' because the second of these has already been used in psychology with a technical meaning and might lead to misunderstandings.

CHAPTER VIII

The Launching Effect seen as a Whole

The method of genetic analysis which we have followed in previous chapters has enabled us to pick out certain features belonging to the structural organisation of the Launching Effect. The results obtained have been set out briefly in Summaries Nos. 1 and 2. Although these conclusions are important for our understanding of the Launching Effect, they nevertheless give us only an incomplete picture, a mere outline, since they do not account for its specific character. The reason for this is not far to seek. The analysis which we have carried out cannot do more than reveal the fact that the two movements are united; it cannot give any idea of the specific nature of the link. This is a property of the whole as such, and is bound to disappear when stimulus-conditions are simplified in any way. Thus the only way to understand the launching impression as it really is is to study directly the spontaneous descriptions given by observers. This will involve elucidating the meaning of these descriptions and discovering the specific feature of the structural organisation to which they refer. We shall then be able to apply the same procedure to the Triggering Effect, which in fact turns out to be closely related to the Launching Effect.

1. THE LAUNCHING EFFECT

When subjects try to describe as accurately as possible what happens in the Launching Effect they use stock phrases, the general import of which is always that *they see the blow dealt by object A drive away object B, launch* it or *push* it away. It is what I have called an 'impact-which-launches' (see p. 67).

It is on the basis of these descriptions that we shall have to build up the theory now to be developed. We shall also have to take into account all the contributory data which we have already acquired.

Now these data enable us at the outset to call attention to an odd fact. As we have seen, it is necessary to consider the striking and the pushing away as processes which include the movements which bring the objects together and separate them again, and the standard description in the end amounts to an assertion that it is object A's movement which

displaces B! This is a startling thing to say and seems to run counter both to reason and to ordinary observation. The phrase really implies two propositions, one suggesting the continuity of the movement and the other the fact that it belongs to object A. Now both seem quite untenable; for in the first place the impact clearly marks the end of the movement of object A and the beginning of that of object B, and in the second place it seems inconceivable that the movement of object B should belong not to B, which is moving at the time, but rather to A which has stopped.

We find ourselves with a complete paradox. Yet I think that these difficulties are specious rather than real; the second proposition is nearer the truth than it appears. In fact it is precisely here that the crux of the matter is to be found.

We must ask ourselves, first of all, to what extent and in what sense the movement of the motor object must be considered to be really finished or completed phenomenally at the moment when this object stops.

That we are concerned in the Launching Effect with two distinct events is unquestionable. It appears so to all conscientious observers, and this obvious truth is confirmed by the fact that, as we have seen already, there is a qualitative difference between the movements as a result of their different polarisation.

It is no less clear, however, that these events are not simply juxtaposed; they form an ensemble, a whole, whose character is clearly indicated in the term 'impact-which-launches'. In view of the regularity with which such expressions occur, and the standards of precision of those who use them, it is hard to believe that this phrase is inadequate; the only alternative is to assume that there is a *continuity* between the impact-event and the pushing-away event.

Here are some examples: the changes of shape seen in clouds or cigarette smoke, changes in people's facial expressions, changes in the bodily position of men and animals, the changes of shape in dough when it is kneaded, in clay when it is moulded, in a balloon when it is blown up, and so on.

Such metamorphoses are easy to produce in controlled experimental conditions, and my colleagues and I have done extensive research on this subject. The whole question is closely connected with the problem of activity which was discussed in the Introduction. The easiest procedure for demonstration is to use the stroboscopic method; indeed this has been applied on various occasions to the study of this kind of phenomenon.[2] Here is an experiment in this connexion which will serve to illustrate the point which I have in mind.

Exp. 46. The experiment consists in presenting an object, A, which the subject observes for several seconds, and then replacing it abruptly by an object, B, which then remains visible permanently. The apparatus used will be described in Chapter X. Object A was the arc of a circle in a vertical position. The radius of the curve was 3·5 cm., the total length of the arc 55 mm. and its width 5 mm.

Object B was a broad straight vertical line of the same length and widths as object A. The two objects were placed in such a way that, if one were put on top of the other, the arc could be astride the straight line. The observation-distance was about 42 cm.

In these conditions there is not usually any impression of one object being replaced by another. Instead we see the curve *straighten up* or *become* straight. There is thus permanence of object but change of shape. This change is really a process which evolves and which makes a link between the two end-terms (the curve and the straight line), and although the evolution is a rapid one in this case, the effect is as if the intermediate stages were actually presented. In other words, we receive the impression of a progressive transition from one stage to the other; *there is continuity between the two shapes.*

Now this continuity can disappear, and we then receive the impression that one object simply replaces the other. This happens either when there is a marked difference in size between the two objects, or when the qualitative difference is more marked (e.g. if the arc is of 2 cm. radius), or

[2] See e.g. J. TERNUS, Experimentelle Untersuchungen uber phänomenale Identität, *Psychol. Forsch.*, VIII, 1925, 81–136.

again when a sufficient time-interval is introduced between the presentations of the two figures.[3]

The analogy between such metamorphoses and the Launching Effect is obvious. In the latter there are also what amounts to two successive terms which are qualitatively different – the approach-impact and the withdrawal-pushing away. Similarly when there is an appropriate time-interval, there is a simple substitution of one term for the other, i.e. a succession of independent events. Again when one term immediately follows the other there is continuity. The impression that 'it is the impact which launches' seems to imply unity and phenomenal permanence in the same way as does the impression which we described by saying that 'it is the curve which becomes straight'.

An objection, however, could be raised to this comparison of the Launching Effect with the change in shape of an object. In the latter case there is permanence of the object, or at least of its matter, even perhaps of its microstructure. What is more, in the case which I have chosen as an example, a very important formal character is maintained, the character of *being a line.* Whether it is straight or curved, it is still one and the same line which we see. The metamorphosis is then incomplete; it is limited to the change of an 'accidental' character of the object.[4] Is it possible that there is anything similar in the case of movement? Is it not of its very nature a transition process of which each momentary phase is annihilated at the instant when another is born? Can there in this case be any sort of permanence lasting through the metamorphosis – permanence of form or even of matter?

This question in fact involves an over-simplification, and it would be foolish to limit the notion of 'permanent matter' to the sense given to it in unsophisticated thinking. The permanence in this case concerns only certain properties which remain constant in spite of variation in certain others. Thus, for example, when we sound a note of a certain

[3] It is worth noting that the impression of substitution can sometimes occur at the same time as apparent movements similar to those produced when there is a metamorphosis. These movements are not therefore sufficient in themselves to ensure the permanence of the object. See also M. WERTHEIMER, op. cit., pp. 188 seq.

[4] In some other cases the metamorphosis may be more complete. Thus when a circular surface is presented and suddenly replaced by a square surface of the same colour and the same approximate dimensions, the impression is often received that the whole mass changes shape. The 'matter' is permanent in this case, and certain formal elements also, but these are reducible to their two-dimensionality, their position, their microstructure, and so on.

pitch and gradually change it, there is the impression that it is the heard note which changes pitch. Now it is obvious that it is not really this note which has been changed; a different note is involved or a continuous series of other notes which succeed the first. The permanence, the maintenance of the identity of the note-object, does not lie in the permanence of matter in the ordinary sense of the words, but in the continuity of impression and the permanence of some characteristics common to the successive notes – their intensity, their timbre, and so on. This is sufficient, in certain conditions, to create the appearance of a fundamental identity.

In the same way, in the case of the Launching Effect, the approach-impact and withdrawal-pushing away follow one after the other without interruption, and although they differ qualitatively they have certain common properties: they are both movements; both are in the same direction; they are in contact spatially and temporally at the point of impact; they travel at the same speed, and so on. This is what constitutes their permanent 'matter', and it is this that Duncker and Metzger, using a term introduced by Minkowski, have called the common 'world-line' ('Weltlinie') of events.[5]

Thus it seems possible to conceive of the Launching Effect as constituting a case of *metamorphosis*, a metamorphosis of process rather than of things. The Launching Effect will then have to be considered as a unity, but one which evolves; and in that case the pushing away will be a continuation of the impact, or, to be more accurate, the impact will undergo a sort of qualitative evolution and continue to exist in the pushing away.[6]

On this basis we can understand how it is that the two phases are distinct, and that one seems finished at the moment when the other begins. There is in fact something which is finished, the approach-impact, and something which begins, the withdrawal-pushing away; hence comes the duality. We can understand likewise how it is that these two events form an organic whole, since one appears to be produced as

[5] See pp. 16 and 17.

[6] It should be noted that the process of evolution is not limited to what occurs at the moment of impact. It continues for much longer than in the case of the curve and the straight line, for even the approach and the withdrawal themselves must be considered as evolutional processes, as we saw earlier. Also when the paths are sufficiently long, the process of evolution extends to the beginning and end of the polarisation of the movement in relation to objects B and A respectively.

a result of the evolution of the other. There is diversity and yet continuity. These conflicting ideas are reconciled in the notion of *becoming*; and it is the notion of *becoming* which justifies us in saying that we have before us *a single process, which successively takes on different aspects.* This phenomenal *becoming* is simply a translation of the complex stimulus-conditions which give rise to the launching impression. These conditions, as we have seen, can usefully be divided into two contrasted groups, those which favour segregation and those which make for integration in a single whole (see Summary No. 2).

Opposition of this kind between these tendencies makes the formation of a uniform process impossible, but it seems that, according to the different proportions, different states of equilibrium can be set up which reflect the degree of antinomy between the conditions. One of these states of equilibrium would consist of a simple subdividing of the whole into similar parts, e.g. the case of a single movement in two stages. Others would have as their special character an emphasis on differentiation of the parts, and in these cases the link between the parts would have the character of a *becoming*, as in the Launching Effect and in all cases of phenomenal metamorphosis. This phenomenon of *becoming*, which is all-important in our experiments, reflects, as can be seen, certain conditions of structural organisation which can be determined exactly.

It need hardly be emphasised that something of this kind is found in all cases of launching. Whether the first stage of the operation consists in an approach-impact, as in the Type case, or in a dilatation of the motor object, or in a simple transportation, as in the case of launching-by-expulsion, the movement of the motor object is always qualitatively very different from a withdrawal-pushing away. Yet there is always a continuity as well; it is always the motor object which 'drives away' the passive object. From what has been said it seems that the notion of metamorphosis is applicable in a general way to the Launching Effect as such.

This conception of the withdrawal-pushing away as the prolongation, after metamorphosis, of the pre-existing movement of the motor object is not sufficient to dispose of all the difficulties mentioned above. It involves the assumption that the movement of withdrawal can be considered as performed by the motor object and not by the projectile, which seems odd, to say the least. On the other hand, if we grant for the moment that this is so, we have to ask ourselves what part is then

played by the projectile as such. The hypothesis of metamorphosis will clearly prove of value only if we succeed in finding a satisfactory solution to these two problems. The questions involved are difficult and need study. I shall begin with the second.

It is easy to show that the performance of a movement by an object does not necessarily imply that this movement belongs to the object. That this is a possibility is a matter of ordinary observation; it is forced upon us in particular by all the cases which can be grouped under the title 'Transport Effect'. (These will be discussed in more detail when we come to consider the Entraining Effect.)

The Transport Effect occurs whenever we see an object transported by any sort of vehicle – a sack on a wheelbarrow, a traveller in a car, a horseman on a horse, and so on. In all these cases, the image of the object transported moves across the retina, yet the movement of this object does not belong to it from a phenomenal point of view; otherwise we should not have the impression of transport but of two objects simultaneously travelling along parallel paths. The movement *belongs* to the vehicle, while the transported object remains intrinsically *motionless* and seems simply to *share* in the movement of the vehicle. Thus in certain conditions there is a dissociation between the performance of movement and its ownership.[7]

Now it is clear that such a dissociation is also found in the Launching Effect. Object B appears completely inert; it does nothing, nor does it display that appearance of activity which ordinarily characterises moving objects, since it is the blow dealt by object A which drives B away and which makes it change its position relative to object A. Indeed this is what gives the phenomenon its special character; it is the change of position as such, and only this change of position, which belongs to object B. The kind of displacement which occurs depends entirely on the way in which B is *driven away* by A. Object B is *in movement* but the movement does not belong to it.

In other words what happens to object B seems, from the phenomenal point of view, to be *a purely spatial occurrence* which is not temporally determined on its own account; the temporal conditions in which this change occurs are fixed by the speed at which object A pushes object B away.[8]

[7] For further details on the Transport Effect, see Chapter IX, 2.

[8] In future I shall use the term 'displacement of the object' to indicate a purely spatial change; it will therefore not imply in any way the presence of a *phenomenal movement* belonging to the object.

This distinction between the *phenomenal movement* of the object – the kinematic process as such – and its simple *displacement* is, I think, all-important here. Incidentally, however illogical this distinction may seem, we can to some extent understand it if we reflect on the classic distinction between the direct perception of movement and the indirect perception of it in cases where the necessary minimum speed has not been reached. There too we have an impression of a change in position of an exclusively spatial kind, similar to that which I have in mind here.[9] It is true that in this case there is the perception of a displacement which has been accomplished and is terminated, while in the launching case we are concerned with a change which is in process of taking place, but everything seems to show that such a change is not necessarily incompatible with the dissociation which we are considering.

Moreover there are plenty of analogies between the present case and certain others found in the field of static perceptions. Thus an ornamental border, such as the bevel on a mirror, or the moulding round the edge of a panel, is clearly set in a definite pattern, e.g. a rectangle, in phenomenal space; yet in so far as the ornaments are perceived as simple 'borders', this shape does not *belong* to them, but seems to be that of the objects which they are decorating. In other words, the bevel or the moulding becomes one with the contour of the object; the border *shares* in the shape of the object. Here then occurs a dissociation of shape similar to the dissociation of movement in the case of the Launching Effect (or the Transport Effect).

A number of familiar observations confirm the validity of this distinction. It is a strange but well-established fact that an object can undergo an apparent movement without seeming to change its position.

The best-known case of this is that of galvanic vertigo resulting from the electrical stimulation of the labyrinths of the ear. A vertical luminous line, isolated in a dark room, appears to suffer an abrupt angular deviation towards the cathode at the moment when the circuit is closed, and then seems to continue its rotation in the same direction during the whole time that the current is operating. Yet this line does not seem to depart any farther from the vertical than it did in the first moment.[10]

[9] In so far as the temporal factor plays any part, it is in connexion with the length of time taken, not with the speed of movement.

[10] See in this connexion e.g., W. NAGEL, *Handbuch der physiologie der Menschen*, Bd. 3, F. Vieweg und Sohn, Braunschweig, 1905, p. 767.

Similar phenomena can be observed in the case of after-images of movement. When a moving object is suddenly halted, it seems in certain conditions to retreat for a moment. But when the object stops near a fixed reference point, it does not appear either to approach or to move away from this point; the distance which separates them remains unchanged.[11]

Whatever the theoretical interpretation of this phenomenon, the fact itself cannot be doubted, and this is the only thing which interests us here. If this is so, and the object can maintain the same relative position and still appear to move, there should not be any difficulty in accepting that the change in position of an object and the movement which brings about this change in position may coexist as distinct data.

This dissociation is only a special case, in the kinematic field, of the phenomenon of *duplication* (or double representation) which occurs so often in the field of static perceptions. In the Launching Effect this dissociation is seen in the fact that the movement physically performed by object B appears simultaneously under two different guises: (i) as a movement (belonging to object A), (ii) as a *change in relative position* (by object B). We may also mention the familiar examples from the well-known work of Katz. Here, in the cases of transparent colours and of projected shadows, the same combinations of stimuli can simultaneously give rise, in certain conditions, to two distinct impressions – the colour of the object seen through the screen and that of the transparent screen itself, or the intensity of illumination and the colour belonging to the object which is illuminated. It is true that to produce these dissociations special conditions are required; the screen and the object have to be placed in different spatial planes, the object must overlap the screen or vice versa, and so on. The same applies to the present case, however, since the dual aspect of the movement performed by object B (in the Launching Effect at least) is clearly established only when there is a previous movement of object A and when there is combined action by factors of integration and segregation. Moreover the respective influences of these factors are easily seen in the resolution of their conflict, which takes the form of duplication. For this resolution to a great extent meets the demands both of the integrative influence of the movements and of the segregative influence of the objects. The integration favoured by the movements is seen in the fact that they are united –

[11] See also a very curious case described by W. METZGER, Beobachtungen über phänomenale Identität, p. 58.

the second movement appearing as a prolongation of the first. The segregation favoured by the duality of objects is seen in the difference between the part played by the two objects – the motor object moves, while the other is simply displaced.

The points which have just been made will help to resolve our next and final problem. The difficulty is to understand how the movement of withdrawal belongs to the motor object even though after the impact this object is motionless. The apparent contradiction between the fact that object A is motionless and the fact that a movement belongs to it seems less of an obstacle now that we know that a movement is not to be identified purely and simply with a change in relative position. We may wonder, however, how a movement can 'belong' to an object without that object appearing to 'be' in movement.

In connexion with the Launching Effect, the question in fact arises in a somewhat different form; for if we take into account the fact that the movement is continuous, the problem is that of the *apparent prolongation* of a movement which clearly belonged to the object before it became motionless; this is quite different from a movement belonging in the abstract to a motionless object. Nevertheless the expressions involved still seem contradictory unless we say that the movement is a phenomenon *sui generis*, which may in certain conditions 'detach itself' from the objects. If this is so, we can now understand how the unity formed by the moving object in the first phase of the experiment can separate out at a given moment (i.e. at the time of impact) and how the movement can last for a certain length of time after the object has stopped.[12] The thesis of absolute 'separability' of movement has of course been defended by Wertheimer[13] on the basis of his stroboscopic research on the pure phi phenomenon; but it has been contested by others, and I do not propose to discuss it here. A discussion of this sort is liable to degenerate into empty argument unless fresh facts are adduced.

For this reason it will be enough to mention a curious observation which we made in the course of research on other matters. This observation is one which only indirectly touches the problem of 'pure move-

[12] This would not necessarily imply that the movement has ceased to belong to the object, as can be seen when we study the breaking off of part of an object from the whole. In this case, the 'pieces' continue for a certain length of time to look like 'parts-of-the-object', and it is only at a later stage that we see a duality of objects, each having its own shape. It is easy to verify this by performing appropriate stroboscopic experiments.

[13] M. WERTHEIMER, op. cit., pp. 221 seq.

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[11] See also a very curious case described by W. METZGER, Beobachtungen über phänomenale Identität, p. 58.

a valid argument against its truth. Moreover we must point out in this connexion, and in a general way with regard to all the problems considered in this chapter, that the difficulties encountered in the field of the perception of movement originate in the first place from a fundamental confusion, a confusion between the concept of phenomenal movement and that of physical movement. Now the more psychological knowledge we acquire on the subject of phenomenal movement, the more evident it becomes that we have to regard it as a specific psychological fact. It is a datum of experience to which a physical movement can give rise (although it can be produced in the absence of such a movement), but is something quite other than a mere copy or reproduction on the psychological plane of what goes on in the 'external' world. Thus, in the same way as sounds and colours on the one hand and the corresponding physical 'vibrations' on the other are governed by completely different sets of laws, so the same is true of phenomenal movement and physical movement.

Now the possession by the motor object of the withdrawal movement must be directly connected with the inversion of polarity in the movement of the projectile. The importance of this inversion for the Launching Effect has been shown by the numerous experiments already mentioned in this connexion. Inverse polarisation in effect links the movement with its point of departure by the character which it has of appearing to 'come from' somewhere. It seems probable that this is the necessary condition for the movement to belong to the object which forms this point of departure. The comparison of the Launching Effect with the Relay Effect justifies this conclusion, for the latter is produced when the experimental conditions are of a kind to maintain the direct polarisation of the second movement. In this case each of the two movements belongs to the object which performs it.

Thus there is in this respect a considerable difference between the two effects. In other respects the Relay Effect is close to the Launching Effect, in that the movements which constitute it form an organic whole and are apparently also linked by a *becoming*. Indeed does not the specific character of the Relay Effect lie in the fact that the movement of one object ceases to belong to it at a given movement and *becomes* the movement of another? This interpretation corresponds well with the impression that the first object 'gives' something to the second at the moment of contact.[15]

[15] See W. METZGER, Beobachtungen über phänomenale Identität, p. 14.

ment', but is much more immediately relevant to the Launching Effect; and that is what specially concerns us for the moment. Here is a description of the experiment.

Exp. 47. This experiment was carried out by the projection method. The two objects A and B are both present. Object A is a simple coloured spot of light, occupying practically no space, at a distance of 6 cm. from object B. Object B is a red circle of light 3 cm. in diameter. The spot of light, object A, begins to move at a speed of 10 cm. per sec. in the direction of the centre of object B, but disappears suddenly before reaching the edge of the circle. (The observation-distance was increased to 2·50 m. in order to ensure that A looked to be no more than a dot.)

When the dot A disappears at a very short distance (2 mm.) from object B, observers generally have the impression that it continues its movement and 'goes behind' object B; this impression is the same as the first phase of the ordinary Tunnel Effect. There is a phenomenal permanence of object A and of its movement. On the other hand, when the distance between the edge of the circle and the place where object A disappears is greater, 5 or 6 mm. or even more, various things can happen. Sometimes the impressions simply correspond to the objective situation; in other cases one has the impression that the spot of light goes behind a dark screen beside the circle. Sometimes, however – and this is what is interesting – one has the impression that the spot disappears while *its movement* continues right up to the circle, and then is lost 'behind' it.[14]

This experiment has been repeated on many occasions with subjects thoroughly schooled in scientific observation, and there is no doubt that such a phenomenon is at least *possible*. It follows that the movement of an object is liable in some circumstances to survive phenomenally the removal of this object, and there can be apparent *continuation* of the movement of an object which has ceased to exist and is consequently not itself being displaced.

The relationship between a case of this sort and a case of launching is immediately obvious, and clearly confirms our theory; for if the movement can seem to be prolonged after the object is phenomenally annihilated, it surely can similarly seem to be prolonged after the object has stopped. The last experiment shows at any rate that we cannot consider the logical contradiction apparently involved in our thesis as

[14] See A. C. SAMPAIO, op. cit., p. 15.

The process is thus linked, after the impact, with the two objects, and stands in a different relation to each; in this way there is the appearance of two distinct events. It is this which is expressed in the phrase 'The blow *dealt* by object A *pushes away* object B' – the term 'pushes away' implying both the intervention of object A and the change in position of object B.

Although in the Launching Effect we are concerned with two distinct events, it would nevertheless be a mistake to speak of 'two movements'. We see now that the Launching Effect consists, from a phenomenal point of view, of a *single movement*, that of the motor object.[18] If in the previous chapters I have continually spoken of two movements, that was justified only because we were then in the process of analysing and we had not at that stage the right to take account of the data obtained from examining the Launching Effect seen as a whole.

This is no longer the case. It is therefore important that we should reconsider certain expressions used, and make a number of points more precise.

In particular, we can now give a more precise answer to the question, which we were considering in Chapters III and IV, as to what is the significance of the segregative and polarising influence of the objects. The segregative influence does not bring about the establishment of a distinction between 'the two movements'; instead we should regard it as one of the conditions which make for a double representation of

it is the movement of the motor object which seems to bring about the displacement of the projectile.

As for the double aspect, the 'two faces', of the movement, a very simple example may perhaps help to bring out what is happening. If we draw the outlines of two adjoining shapes, e.g. a square and a triangle, in such a way that they have one side in common, it is still possible to have the impression of two complete shapes. The same line – the one which they have in common – appears both as a side of the square and as the base of the triangle. This example serves simply to indicate a general point; we shall meet other similar cases in the course of this book.

[18] This clarifies matters a great deal. We can now understand better why there is such a close relationship between the Launching Effect and the continuous movement of a single object. We can also understand the nature of the characteristic 'break' which occurs in the movement of the projectile at the moment of impact in some cases of Launching-in-flight (exp. 17, p. 70 and note 17, p. 71). Indeed the movement of the projectile ceases at this point to exist phenomenally, since the movement which follows the impact has the appearance of being a movement of the motor object. Thus the fact of the 'break' lends support in a very interesting way to the theory that the movement belongs to the motor object.

If we look at the Relay Effect in this way, the formula which Metzger proposes for the causal impression, and for the Launching Effect in particular,[16] seems to fit it very well; but the structural organisation of the Launching Effect itself is quite different, as we have already observed and as we shall see again from what is to follow.

We are now in possession of all the elements required for solving our problem. Let us recall them briefly.

1. It is possible to conceive of the Launching Effect as a continuous process, undergoing at the moment of impact a qualitative evolution, as the result of which the two phases of the process present aspects which are clearly different.
2. We can claim that, as a result of the conditions in which it is produced, the physical movement of the object struck gives rise to a double representation. This movement appears at one and the same time (*a*) as a continuation of the previous movement of the motor object, and (*b*) as a change of relative position (a purely spatial withdrawal) of the projectile in relation to the motor object.
3. There is nothing impossible in the fact that the physical movement of the object struck appears as a continuation of the previous movement of the motor object even though after the impact the latter is motionless.

If these three conclusions are taken together, it is possible to see how they can be synthesised into a very simple theory of the Launching Effect.

At the moment of impact, the movement of the motor object appears to extend to the projectile, bringing about its displacement in space. This amounts to saying that from that point on the movement presents a double aspect; we see it both as a continuation of the movement of the motor object before the impact, and as something which brings about a change in position of the projectile.[17]

[16] See p. 17.

[17] In order to avoid all misunderstanding, it is important to make the following point. The duplication discussed in these last few pages can be viewed from different angles. When considered from the point of view of the stimulus-conditions, it refers to the physical movement of the *projectile*; it is this physical movement which is represented in two ways. On the other hand, however, when considered from a purely phenomenal point of view, it is the movement of the *motor object* which has a double aspect. This arises from the fact that one of the ways in which the physical movement of the projectile is represented is as a continuation of the movement of the motor object. It necessarily follows, therefore, that

displaces object B'; and now that we understand it properly we can appreciate how accurately this formula reflects the phenomenal data.

To sum up, the essential point in our theory is the view that the movement of the motor object undergoes an 'extension' (in the sense already explained) on to the projectile; it is during this 'extension' also that the reproductive character of the causal impression appears, as we shall see later (Chapter XIV). Since this fact is of such importance, it will, I think, be helpful to introduce a special term for it. I shall call it *ampliation of the movement.** What I mean by this – the reason will become clear later – is the *creating* or *establishing* of the extension on to a second object of the already existing movement of a first object, in such a way that this movement brings about the displacement of the second object.

Such, then, is the structural interpretation which seems to be required for an understanding of the impression of the impact-which-launches. Some will perhaps think that this theory is over-subtle. In my opinion, however, this is not mere 'arm-chair' speculation; the distinctions which I have made are not just the outcome of ingenious theorising, but seem, however refined, to be demanded by the facts. Moreover we shall be able to see from what follows that our theory accords completely with the results obtained when we study other types of mechanical causality, and this confirms its value and also increases the area of its applicability.

As a matter of interest, let us now retrace our steps in the opposite direction along the path which we have followed. There is no better way of making clear once again how well the findings of the preceding chapters link up together to form the theory of the Launching Effect.

If it is ampliation of the movement which is the essential feature in the causal impression, we can deduce the following consequences:

1. Since ampliation is simply the establishing of the 'extension' of the movement of the motor object, it necessarily presupposes the preexistence of this movement; this implies the *hierarchy of priority*, with the consequences which it entails.

2. Ampliation is conceivable only if a distinction is established on the phenomenal plane which corresponds to the duality of the movements performed physically by the objects. This distinction is assured by the

* *L'ampliation du mouvement.* See Glossary.

the physical movement of the projectile, and consequently as one of the conditions which gives the movement of the motor object its dual aspect.

As for the polarising influence, by reason of which the 'movement' of the projectile is polarised inversely, this is clearly a matter of *spatial* relations; it is thus the displacement of the projectile which has the character of withdrawal (the displacement being brought about by the movement of the motor object). In this connexion we should remember that it was as a function of polarisation that we defined the 'radius of action' (p. 54). Now as the projectile moves farther away from the motor object various changes are in fact produced. Not only does the polarisation cease to be inverse, but in addition the phenomenal duplication disappears; in other words, the movement performed by the projectile is then its own, and no longer belongs to the motor object. This, however, creates no special difficulty, since the two changes necessarily occur simultaneously, at any rate if we assume that inversion of polarity is an essential condition for the ownership by the motor object of the movement performed by the projectile. As was indicated earlier, this is almost certainly the case.

We may note also that the idea of a qualitative evolution which takes place at the moment of impact (the metamorphosis of approach-impact into withdrawal-pushing away) is now much more easy to understand. The continuity which I have emphasised is more fundamental even than one might have thought, since only one *movement* is involved. It is this movement which, as it develops, undergoes an evolution. Although at the beginning it appears as a simple approach, later it really does take possession of the projectile – one might almost say appropriates it – in the course of bringing about its withdrawal.

Finally, we can now see that it is inaccurate to say that the blow dealt by the motor object appears as the cause of the movement of the projectile, or that there is in the Launching Effect a 'passage' or 'transference' of the movement of one object on to another, as in the theory put forward by Duncker and Metzger.[19] It would be more correct to say that the blow dealt by the motor object appears as the cause of the *displacement* – a purely spatial phenomenon – of the projectile. This brings us back to the phrase which we made the starting-point for this discussion. We took the descriptions given spontaneously by the observers and expressed them by the phrase, 'It is object A's *movement* which

[19] See pp. 15 seq.

the whole gamut of phenomena which can stretch from an appearance of two quite independent events to a clear impression of the second event being entirely produced by the first.

The question therefore arises as to how this influence is to be understood and what is its exact significance. We might suppose that we have here a phenomenon of an extremely general kind, which can manifest itself in the most varied conditions, and which for the most part belongs *outside the sphere of perception of movement.*

Now the results of our series of experiments suggest quite otherwise. As will be seen later, we have never observed triggering in our experiments on purely qualitative causality, i.e. when all movement was eliminated. *It is a remarkable fact that all cases of triggering which* occurred in the course of our research have been produced in connexion with experiments which also gave impressions of launching, or which might lead to such impressions if a slight change were made.[20] The Triggering Effect, therefore, like the Launching Effect, must be considered as a form of link between two *movements.*

The special characteristic which distinguishes the Triggering Effect from the Launching Effect lies in the autonomous character of the movement *triggered off.* Thus all the experimental modifications that favour this autonomy result in the substitution of the Triggering Effect for the Launching Effect. The Triggering Effect appears in particular when an ascending hierarchy of speeds is introduced, when the relative orientation of the movement is altered, when the distance between the objects is increased in the case of 'impact at a distance', or again when the second movement is in the form of a contraction of the object, and so on.

On the other hand, the Triggering Effect is also quite clearly distinct from the Relay Effect, although the second movement is autonomous in both cases. The character of dependence displayed at the start by the movement which is triggered off does not exist at all, strictly speaking, in the Relay Effect, which involves something more like transferring or taking over. Moreover, parallel to this difference between the impressions, there is another difference. In the case of the Triggering Effect, polarity is inverted, while in the case of the Relay Effect the two movements are polarised in the same way.

All this clarifies the problem of the Triggering Effect, and enables us

[20] This was true, in particular, of the experiments on 'qualitative causality' reported in Chapter XV.

twofold influence of the objects in bringing about both segregation and polarisation.

3. On the other hand, since ampliation consists of the apparent prolongation of the movement of the motor object after the impact, there must also be continuity between the two movements. Because of the action of the factors of segregation and polarisation, however, this continuity can occur only in the form of a qualitative evolution, a metamorphosis of the original process. Now as such a form of unity is undoubtedly rather difficult to produce, the forces making for integration must be particularly strong as regards spatial, temporal, and kinematic conditions.

4. The continuity of the process clearly presupposes that the movement performed by the object launched belongs to the motor object; and it is likely that this is made possible only by *the inversion of polarity*. This continuity is strengthened by a *descending hierarchy of speeds* which, while accentuating the dominance of object A, must at the same time accentuate the belonging of the movement to object A, since the two go together.

2. THE TRIGGERING EFFECT

The phrases which observers use when they describe the Triggering Effect are less precise than in the case of the Launching Effect, but their general import is to suggest two things. In the first place they assert that the active object 'exerts an influence over the passive object', that it 'does something' to it or, in a passive form, that the second event 'depends on' the first. In the second place they assert that this influence limits its action to the beginning of the event produced, which thereafter proceeds in an independent manner. As we said earlier in connexion with the cases of triggering which we studied in detail, the movement of the passive object is autonomous in such cases without being spontaneous; in other words it is independent of the movement of the active object in its execution but remains dependent on it for its origin.

The 'influence' which constitutes triggering remains vague and indeterminate, therefore, and its effect is very restricted. Moreover it shows very marked differences of degree, and this often makes the subjects in the experiments hesitate as to the nature of the phenomenon. Is there really a positive influence, or is the antecedent only the 'occasion' of the appearance of the consequent? Is it a mere triggering or a real launching? The fact is that observers group under one heading

ment in our experience is very much greater than is commonly supposed. The proof of this will appear during Chapters XI and XV. We shall there see that, when changes in size and shape are included as movements, the sphere in which movement plays a part increases remarkably. It is thus quite possible that these inferior forms of causality do in fact frequently occur, and play an important part in everyday life.

to judge its significance, which seems to be that of a weakened form of the Launching Effect. The overall conditions in which it occurs being those of the Launching Effect, one would expect from what we have seen with regard to the latter that, in the case of the Triggering Effect too, the second movement would appear as a prolongation of the movement of object A. But this is not actually the case; the second movement *belongs* beyond any doubt to object B, and it is precisely that which assures its autonomy. Thus we may wonder if the impression of initial dependence can be connected with the idea of ampliation.

There does not seem to be any special difficulty in supposing this. When observers talk of the impact or contact of the object 'doing something' to the departure of object B, does this not signify in effect that the beginning of the movement of this object is 'part of' the impact? Could we not interpret this phrase as meaning that ampliation is limited in this case to the very first stage of this movement, to the extremely brief moment during which the proper character of the movement has not yet asserted itself? When, on the other hand, the particular properties of the second movement begin to appear, and clearly differentiate it from the first in virtue of the greatly increased speed, the new orientation, the increased distance between the objects, and so on, the second movement tends to emancipate itself from the protection of the first and becomes autonomous. In other words, we have here an ampliation that is cut short, abruptly or otherwise, according to the amount of difference between the two movements. This is the reason for the many varying shades of impression which appear in the Triggering Effect.[21]

All these vague terms – 'triggering', 'dependence', 'influence', etc. – at least when used in the sphere of external experience – always suggest a primitive form of launching, and they apply only to combinations of *movements*. They represent a weaker or inferior form of causality in contrast with the Launching Effect and Entraining Effect which are the finished products. Only in these latter cases does the specifically *causal* character of 'production' become fully realised.

This unexpected conclusion appears at first sight to curtail very considerably the possibility of perceiving 'influence' or 'dependence' in the physical world. But this view is mistaken, for the part played by move-

[21] We shall find similar very interesting cases when we study the Propulsion Effect (Propulsion Type II) in Chapter XI.

CHAPTER IX

The Structural Organisation of the Entraining Effect

1. THE ENTRAINING EFFECT AND THE LAUNCHING EFFECT

Most of the data obtained so far are applicable to the Entraining Effect no less than to the Launching Effect, and our study of the Entraining Effect is therefore made very much easier. Of particular relevance are the data relating to impact, radius of action, hierarchy of priority, and all factors which bring about segregation and integration.

A special examination of the Entraining Effect is justified, however, because it enables us to throw light on the prime importance of a factor whose influence it is difficult to isolate in other conditions, but which must be taken into account if we are to understand the causal impression fully.

Although the Launching Effect and the Entraining Effect are not very much alike in appearance, they are in fact very closely related. This becomes clear first of all from a study of the conditions in which they occur. These conditions are so nearly the same that, if there is even a small alteration in them, we can pass imperceptibly from one effect to the other, as is shown clearly in exp. 18 (p. 71).

Moreover it is obvious that from a phenomenal point of view the Entraining Effect produces a situation very similar to that which has just been described in connexion with the Launching Effect. It is the movement of the 'active' object which displaces the 'passive' object. The latter performs a movement which does not belong to it, and remains *inert* while the first object *carries it off*.

In an Entraining Effect such as that which occurs in exp. 2 (p. 21), this characteristic is so evident that no special demonstration is necessary. By way of proof, however, I shall mention two experiments, since they are also of considerable interest in other respects.

The first consisted of an attempt to destroy the causal impression by making the movement of object B autonomous.

Exp. 48. This is the same as exp. 2 except that the objects begin to move simultaneously at different speeds. A, moving more rapidly than B, joins it, after which they both move *at B's original speed.*

Part Two: The Entraining Effect

In this section of the book we shall begin by studying the Entraining Effect in its simplest form, i.e. as it occurs in the second of the two Type-experiments.

Next we shall examine other varieties of causal impression, viz. launching-by-expulsion and propulsion, and also the perception of animal locomotion. All these phenomena can be linked up more or less directly with the Entraining Effect, from which they are derived theoretically.

In a final chapter we shall consider causal impressions in the tactile-kinaesthetic sphere. These, it is true, are sometimes of the launching-by-striking type, but the great majority of them belong to the class of impressions derived from the Entraining Effect, and cannot therefore be studied without a knowledge of the latter.

objects move simultaneously and in a similar way after the impact. In this respect the Entraining Effect resembles that very interesting phenomenon from which it is genetically derived, the Transport Effect.

This 'effect' has already been mentioned. The essential feature of it is that a movement which is actually performed by the transported object does not belong to this object, but to the 'vehicle' or transporting object, as in the various examples given during the last chapter.

The theoretical basis of the Transport Effect is simple enough. What is involved, as we know, is a separation of the systems of reference; the transported object is referred to its vehicle, and the vehicle is referred to the surrounding field. To obtain the Transport Effect, therefore, it is necessary to ensure that the transporting object *isolates* the transported object from the space around it. An example of this occurs when one object is inside another, or when there is an obvious break between the object and the surrounding space, as in the case of an apple handed to someone on a plate. The 'vehicle' (in this case the plate) then becomes the exclusive frame of reference for the apple, which will have no movement of its own as long as it does not move in relation to *its own* frame of reference, whatever may be the changes in position which it undergoes when *participating* in the vehicle's movement.[1]

What is involved in this idea of participation becomes clear if we connect it up with the important distinction between the movement of an object and a change in its position. In using the term 'participation' we are referring to the fact that the kinematic process belongs to the transporting object, while the transported object undergoes a 'displacement', i.e. a mere change of position in space, as described earlier. Thus the Transport Effect brings out very forcibly the exact significance of this dissociation, which is of extreme importance for the theory of certain kinds of causal impression.

Something similar clearly happens during the second phase of the Entraining Effect, when one of the objects is carried off by the other. Indeed one observer very rightly remarked in this connexion that although there were in fact two objects, he saw *only one movement* in the experiment, that of object A; object B *did not have* a movement.

This being so, we might expect to see the Transport Effect when, in accordance with the method of genetic analysis, we isolate the second phase of exp. 2. This, however, is not the case. There is no trace of transport; a rectangle is formed by the juxtaposition of the two objects,

[1] See K. DUNCKER, Über induzierte Bewegung, passim.

The results depend very much on the point of fixation. If we follow B, we see it move along autonomously on a continuous and uniform path, while A comes and joins it and then accompanies it; in this case the movement of object A seems to slow down and is sometimes even divided into two parts at the moment of contact. The two objects keep their own movements, and there is no longer any trace of entraining. Equally there is no impression that B brings about the slowing down of A.

These observations can be made over a whole range of absolute and relative speeds. The combinations which we tried out were 16:4, 16:8, 30:7·5, and 30:15 cm. per sec.

When we follow object A, on the other hand, we ordinarily receive an impression of entraining. In that case, however, it is the movement of object B which is divided at the point of impact.

The result thus seems to depend on the attitude adopted by the observer. Fixation of object B necessarily has a decisive effect, since, by isolating B, it prevents the Approach Effect from appearing in the first phase of the experiment, and also brings out the uniformity of B's movement, thus ensuring its continuity.

A second experiment shows that object B's movement does not necessarily lose its autonomy completely at the moment of impact, but may lose it gradually.

Exp. 49. This is the same as exp. 2 except that the two objects both begin to move simultaneously at different speeds. A, moving more rapidly than B, goes to join it; after this they both move *at A's original speed.*

When there is a great difference between the speeds – e.g. when they are 16 and 4 cm. per sec. – so that the movement of B is markedly altered when it adopts A's speed, there is entraining. The phase of movement by object B before the contact is divided off from the subsequent phase. When the change is less marked – e.g. when the speeds are 16 and 8 cm. per sec. – we receive a clear impression that A *accelerates the movement* of B by pushing it; and in this case B's movement retains for a time a fair degree of autonomy. When the difference is less marked still, the two movements are completely independent of each other.

The results of these two experiments will be considered again later.

2. THE ENTRAINING EFFECT AND THE TRANSPORT EFFECT

The great difference between experiences of launching and experiences of entraining lies in the fact that in the case of entraining the two

rolling about on a plate as it is handed to someone, or of a bag of coal shaken by the jolts of the cart on which it is resting.[2]

The Transport Effect is clearly very similar to the Entraining Effect, so much so indeed that, unless one is observing the phenomena in strictly controlled conditions, one might suppose that there was very little difference between them. Yet there is one essential difference. The cases of *pure* Transport (such as that of exp. 31) give no causal impression; there is no impression that the screen *entrains* the disc in the same way as object A entrains object B in exp. 2. The screen *supports* the disc but does not *carry it off*.[3]

Moreover only a slight alteration in the experimental conditions is required to change the result completely.

Exp. 52. For this experiment we need to modify either exp. 50 or exp. 51; it does not matter which. The difference is that in the present experiment the movement of the screen begins *before* that of the disc. The screen travels 1 or 2 cm., and then the disc begins to move as well.

There is a clear causal impression this time; the screen *entrains* the disc. It must therefore be *the temporal priority of the movement of the transporting object which is decisive* in determining which effect is produced.

The causal impression is as transient in this case as it is in exp. 2; it quickly disappears, and sometimes, if the movement of the objects is prolonged slightly, it gives way to the Transport Effect of exp. 51.

In point of fact we had already come to the conclusion that the priority of the movement of the motor object was of cardinal importance in the case of the Launching Effect. Indeed it is indispensable if there is to be a phenomenal duplication (or dual aspect) of the physical movement of the projectile,[4] and hence if this movement is to belong to the

[2] In creating the impression that the transported object participates in the movement of the vehicle (i.e. undergoes a phenomenal duplication) an important part is played by the opposition between (*a*) the tendency towards fusion of the movements and (*b*) the tendency towards their separation (the latter resulting from the fact that the two objects can be distinguished). The importance of this opposition is well illustrated by the last two experiments.

[3] From the physical point of view, however, the movement of the vehicle is clearly the 'cause' of the movement of the transported object; this is another example, and a particularly striking one, of a case where one might have expected a causal impression to appear, but it does not!

[4] We should remember that the phenomenal duplication occurs in the case of the Launching Effect as the result of a conflict between two opposing tendencies. The movement of the projectile tends to *unite with the already existing movement of the motor object*, and this conflicts with the tendency towards separation of the movements resulting from the presence of two objects.

and we simply see it move as a *single* object – an impression which does not at all remind us of that produced by the experiment in its complete form.

Although the Transport Effect does in fact occur frequently in everyday life, where the segregation of the objects is assured by many factors (an important one being organisation in the third dimension), in simplified experimental conditions it is quite a different matter. To produce it special precautions are required, as is shown by the following experiment.

Exp. 50. This experiment was carried out by means of a somewhat complicated piece of machinery which is not of sufficient interest to justify a detailed description.

The transporting object consisted of a white screen, measuring 10 by 15 cm., which could move horizontally at uniform speeds of between 6 and 10 cm. per sec. in front of the complex background formed by the table on which the apparatus was put, the wall of the room, etc. A disc 5 cm. in diameter, of a dark mottled colour, stood out against the centre of the screen and was about 5 mm. in front of it. The disc was started at the same time as the screen, and moved at the same speed and in the same direction.

The result of this experiment is similar to that which occurs in the case just mentioned. There is no Transport Effect. Instead we see a single object begin to move, with the disc constituting 'part of' the screen and appearing as a coloured patch on its surface. When neither is moving, on the other hand, the disc is clearly seen as a distinct object separate from the screen. This is because they are in different planes. Similarity of the states of movement of the two objects thus acts as an integrating factor and is more influential than the difference in the position of the objects in the third dimension.

We next tried to produce a more complete segregation of the objects by changing the previous experiment slightly.

Exp. 51. This is the same as exp. 50 except that, from before the time when the whole combination began to move the disc kept making little vertical oscillations, about 1 or 2 mm. in amplitude, at a frequency of about 5 or 10 per sec.

In these conditions, the Transport Effect becomes fully apparent. *The two objects remain distinct*, but there is still *only one movement*, that of the screen. The disc no longer looks a constituent part of the screen; it seems as if it is 'attached' to it in some way, and appears to 'take part' in its movement. The impression is exactly the same as that of an apple

however, also makes an important difference in other situations where the factors of organisation do not even result in a Transport Effect (e.g. exp. 50 and exp. 2).

In exp. 2 in particular the result of the temporal priority is to maintain the distinction between the two objects after they come into contact. What we see is *one carrying off the other*, although objectively they form from that moment the rectangular block already mentioned. This segregation is clearly a consequence of the first phase of the experiment and is simply 'left over' from the segregation which arose originally as a result of the distance between the objects and their different states (viz. moving and motionless respectively). It is a remarkable fact that this permanence of segregation is found even when the squares are the same colour and form a rectangle of uniform colour after they come into contact. The Entraining Effect is as good in these conditions as in cases where the objects are of a different colour or shape.

It is not difficult to measure the distance for which the segregation of the objects is maintained when we have an experience of entraining, and several experiments have been carried out to determine this.

Exp. 53. This is the same as exp. 2 except that the course of the two objects after the impact can be limited by means of a shutter fitted in front of the slit in the screen. The observer determines by trial and error the point from which the impression of two objects, one carrying the other, gives way to the impression of a moving bi-coloured rectangle.

These observations seem more easy to make when the speeds are fairly slow. By way of indication here are the results obtained by Mi., who was the only subject to take part in the experiment.

Speeds	*Limit* (distance from the point of impact)
3·5 cm. per sec.	12 mm.
6 cm. per sec.	16 mm.
10 cm. per sec.	22 mm.
16 cm. per sec.	33 mm.
28 cm. per sec.	75 mm. (This represented the whole length of the slit)

There is no doubt at all that the speed has a considerable influence on the value of the limits, just as it did when the radius of action was being determined. It is remarkable also that the absolute values in this case are much the same as they were then, except in the case of the highest speed (see Table II, p. 61, Withdrawal Effect, subject Mi.).

motor object. To judge from the case of launching, however, it might seem that this is the only reason why the previous existence of the movement is required; if this were so, the causal impression could be adequately distinguished by the fact that the movement of the projectile belongs to the motor object.

Now these last experiments prove – and they are the only ones that can prove it – that this is not so. The duplication and the 'belonging' also occur in the case of the pure Transport Effect, without there being a causal impression. It follows that the temporal priority of the motor object must be an integral part of the causal impression. It is essential to the causal impression *that the movement of the motor object, while being exclusively limited to this object during the first phase of the operation, should extend to the projectile (the entrained object) at the moment of impact.*

Now we know also that, if the movements are continued after the objects come into contact, the causal impression disappears and is replaced by the pure Transport Effect. Since this is so we are bound to conclude that it is the actual *passing over* of the movement from one object to the other which gives rise to the causal impression.[5] We shall go more deeply into the reason for this in Chapter XIV when the reproductive character of the causal impression is discussed. The impression is in fact limited to *the period during which the extension of the movement is being established*, and it is for this reason that I have introduced this idea into the definition of ampliation (see p. 143).

From these considerations a rather unexpected consequence follows, viz. that the Entraining Effect is more nearly related to the Launching Effect than it is to the Transport Effect. The reason for this is that, in the last analysis, what accounts for the causal impression is the absorption of the movement of the passive object by the *pre-existing* movement of the active one. The two types of causality thus have the same theoretical basis.

We have just mentioned the effect which temporal priority has in bringing about a causal impression, and this seems to be the only influence exerted by this priority as we pass from the Transport Effect of exp. 51 to the Entraining Effect of exp. 52. The priority,

[5] It is important to note that the priority of the movement of the motor object need not necessarily be a strictly temporal one; it can, in certain types of causal impression, be a 'formal' one. See in this connexion Chapters XI and XII.

This view has the great advantage that it once again brings the Entraining Effect into close relation with the Launching Effect, which of course also involves the referring of object B to object A after the impact.

A comparison between the result of exp. 48 and that of exp. 49 will indicate clearly the part played by A's dominance. As was pointed out at the time, the conditions of exp. 48 are those of exp. 49 the other way round. In exp. 48 A adopts the speed of B at the point of impact, and slows down, while in exp. 49 B adopts the speed of A, with the result that it moves faster.

That being so, we might expect that the results would be the other way round also, or in other words, that, since exp. 49 resulted in the Entraining Effect, exp. 48 would result in a 'Traction' Effect. Objectively B has a continuous uniform movement, while A goes to join it, gets behind it, and then follows it. Why then do we not have the impression that B pulls A, or tows it behind? In other words, why does not the movement of A lose its autonomy? Moreover we often receive the impression that the encounter between the objects in exp. 49 produced an acceleration of B's movement before the entraining is complete. Why, in exp. 48, does one not have the opposite impression, that the encounter of A with B puts a brake on A's movement?

At this stage in our exposition the answer is easy. For such an impression to be given, B would have to be *the centre of reference for A's movement after the impact.* This is impossible, since as a result of the dominance acquired by A during the approach phase, A necessarily becomes B's centre of reference when it forms a group with B, and not the other way about.

At first sight it is rather surprising to find that a causal impression of braking never occurs in any of these experiments, although this is one of the most frequent cases of physical causality. We do of course see a slowing down of the movement after the encounter with the obstacle, but we do not have the impression that it is the encounter with the obstacle which *produces* the slowing down. We have already seen the reason for this in the case of exp. 48, which theoretically seemed to provide conditions most favourable for such an impression. The same reason again, of course, reinforced by some others, accounts for the absence of the causal impression in cases where an encounter with a motionless object is followed by a slowing down. Sometimes in these conditions we have the impression that the object 'ought' to have gone farther, or 'wanted' to go farther, than it did, but that is quite a different

When the spatial units given above are converted into units of time, we find that they represent a third of a second for the slowest speed and a fifth of a second for the fastest speed. As a matter of interest it is possible to work out, as we did for the Launching Effect, the distance covered by the total action and the length of the period of transition. Using the figures given in Table II by the same subject for the Approach Effect, we reach the conclusion that when the speed is 3·5 cm. per sec. the action extends for about 30 mm. or approximately three-quarters of a second; when the speed is 16 cm. per sec., the distance covered is about 70 mm. and the time around half a second.

It is quite possible that these findings are in some way related to the radius of action; but if we grant that they are indicative of the total influence exerted by the priority of A's movement they are somewhat difficult to interpret in the present case.

Another effect of this priority is the establishment of a hierarchy for the two objects. As this point has been discussed in some detail in connexion with the Launching Effect (Chapter IV, 3), there is no need to return to it now. All that need be said is that the priority of the movement of A ensures its dominance over B. This is important in connexion with the Entraining Effect also, for we have to explain why the movement of B loses its independence, and why, since the two objects remain distinct for some time, we do not have the impression that they simply move one behind the other after the impact. This question brings us back to the Transport Effect.

We saw that the Transport Effect required special structural relations between the objects, e.g. the inclusion of one in the other, which had the result of bringing the objects into a spatial relationship with each other, and also set up a barrier between the object transported and the frame of reference of the transporting object. It follows logically from this that, in the case of entraining, it is the particular structural organisation of the group formed by objects A and B after the impact which allows A to play the part of transporting object; to be more precise, it is because of the dominance of A in this group that B becomes, as it were, its satellite, and is referred to it during the period of transition.[6]

[6] This dominance, which is due to kinematic factors, can conflict with other hierarchising factors of a static kind, e.g. a difference in the size of the objects. When this difference is large, so that the surface area of B is, e.g., two or three hundred times that of A, the Entraining Effect is certainly less clear and often disappears completely.

The lack of autonomy in B's movement and the Entraining Effect are as clear in these two cases as in the *Type-experiment*. The only differences are to be found in the form which these features take in each case. When there is a descending ratio of speeds, there is the impression that A deals B a blow at the point of impact, and this impression is the more marked the greater the difference between the speeds; the Entraining Effect then seems more like a 'push'. A greater difference still, however (a ratio of 10 to 1 or more), has a segregative influence, as was pointed out earlier (pp. 113 seq.), and divides the phenomenon into the two independent phases – the blow dealt to B by A and the movement of the rectangular block. In this case the causal impression disappears.

When there is an ascending ratio of speeds, the resultant impression is rather a curious one, just as it is in the case of the Launching Effect. Subjects describe it by saying, for example, 'It is as if A tiptoed up behind B', 'It is like a cat creeping up to a mouse, and then pouncing and carrying it off' (compare this description with those on p. 121). The impression of a blow is replaced by mere contact, but the Entraining Effect is still fully apparent. It is thus clear that this character is largely independent of a change in speed at the moment when the objects come into contact.[7]

Once again it should be stressed that the impression of entraining in the case where there is an ascending ratio of speeds is in conflict with what we have learned from everyday experience. From the point of view of mechanics we have here a paradox, and it is clearly for this reason that subjects resort to these somewhat droll comparisons in order to make sense of the unusual appearance of an Entraining Effect which, despite its paradoxical character, cannot be seen in any other way.

It is also possible to produce a mechanical paradox in the reverse situation, when the outcome of the impact is to decrease not only the initial speed of the motor object, but also that of the object struck.

Exp. 55. This is the same as exp. 2, except that the two objects begin to move simultaneously at different speeds. A, moving more rapidly than B, joins it; after this they both move at a speed *lower than that of* B. The original speed of A was 20 cm. per sec., that of B 10 cm. per sec., and the common speed of the two after the encounter was 5 cm. per sec.

[7] It is also clear from exp. 48 that making the speeds equal is not sufficient to produce the causal impression, since B's movement does not in that experiment appear to be the cause of A's movement after the impact.

matter from causality, and probably has some connexion with the properties of the radius of action.

The fact that the objects used in the Type-experiment of entraining are the same shape (i.e. two identical squares) has shown up clearly what is the effect on the impression of the temporal priority of the movement of the motor object. It influences it in two fundamental ways, i.e. by bringing about (i) segregation and (ii) hierarchisation. These influences are not obvious until we turn from the Transport Effect to the Entraining Effect, since in the Transport Effect segregation and hierarchisation are ensured by other factors. Nevertheless these factors are clearly operative in a large number of cases, and in all cases of entraining. Thus temporal priority is sufficient to ensure a causal impression irrespective of the shape of the objects, their size (to a large extent), and the structural relations between them, e.g. inclusion of one in the other, juxtaposition, and so on. All that is needed is that they should come into contact with one another, and move in the same direction at the same speed. This explains why we do not need to take so many precautions in order to produce experimentally a successful causal impression of entraining as we do to produce a pure Transport Effect.

3. THE RELATIVE SPEEDS AND THE ENTRAINING EFFECT

It is clearly necessary for the Entraining Effect that the movements of the two objects after the impact should be similar in both direction and speed, although there is a small amount of tolerance in this respect, as is shown by the results of exp. 18 (p. 71). The question arises, however, as to how much the impression of entraining is affected by a difference between the speed of object A's movement before the impact and the movement of both objects after the impact. This question is all the more worth considering since it is in virtue of its pre-existence that the movement of the first object is the driving force and entrains the passive object. Here, once again, we are touching on the problem of what relations of similarity must exist between 'effect' and 'cause'.

The following experiment provides some relevant data on the subject.

Exp. 54. This is the same as exp. 2, with object B remaining motionless until the moment of impact. Whereas in the Type-experiment, however, the two objects then moved together at the original speed of A, in this case they move at a lesser or a greater speed. The speeds used for the two parts of the experiment were 16 and 4 cm. per sec. or 4 and 16 cm. per sec.

Here, too, it is possible to obtain a clear impression of traction, especially at the moment when the second object starts. It is as though the first object were towing the other on the end of a piece of string. The impression, however, is not as good as in the previous experiment. This is undoubtedly because of the separation of the objects in space; the observer has to be prepared to look at the experiment as a whole if the Traction Effect is to occur. An analytical approach, which can creep in very easily, is fatal to it.

A third experiment brings out particularly clearly the importance of the priority of the movement of the motor object.

Exp. 58. This is the same as exp. 2 except that, when object A has joined object B, it returns to its starting-point accompanied by object B.

The results of this experiment depend on the speed of the movement. When this is fairly slow, i.e. less than about 12 cm. per sec., the impact clearly dissociates the two parts of the to-and-fro movement performed by A. First we see A join B, and then we see the combination begin to move in the opposite direction. The change of direction acts as a factor segregating the two phases of the experiment, and there is no traction. A more rapid movement, on the other hand, e.g. one of 30 cm. per sec., produces a very different effect. The two phases form an uninterrupted whole, and we see A 'hook' B on and carry it off as plainly as it entrains it in the Type-experiment. The speed of the movements, acting as a factor of integration, serves to establish *continuity* of A's movement in spite of its change of direction; the first phase appears as the beginning of a movement which is continued during the second phase, and as a result A's movement begins phenomenally before that of B.

Traction is thus only a special case of entraining. Its specific character consists simply in the fact that the motor object takes a position *in front* of the other; the structural organisation of both kinds of causal impression is similar.

The results are very similar to those of exp. 48. When we follow object A with our eyes, there is a clear Entraining Effect, whereas if we fixate object B it tends to be destroyed.[8]

It need scarcely be pointed out that when the Entraining Effect occurs in these conditions it is even more absurd than it was in the previous experiment. This is another indication that acquired knowledge is of little importance in such matters.

4. THE TRACTION EFFECT

Mention was made in section 2 of the case of the 'Traction Effect', i.e. the case where we receive the impression that one object 'pulls' another or 'tows' it behind.

After carrying out our first experiments on entraining we often asked ourselves whether there was a causal impression corresponding to the action of towing. Several attempts were made to produce one, but they were unsuccessful until we understood the theoretical basis of the Entraining Effect and the importance of the priority of the motor object's movement. Afterwards the application of this principle was sufficient to produce positive results – results which demonstrated the principle's validity. Here are three typical traction experiments.

Exp. 56. This is the same as exp. 2 except that object A *passes* object B. As soon as it has passed it, the two objects move side by side at the same speed. On this occasion A is therefore in front of B in relation to the direction of movement. The speed of A before the impact was 16 cm. per sec., and that of the two objects together was 7 cm. per sec.

In these conditions we see object A pass over object B, hook it on behind and tow it – an impression exactly analogous to that of entraining.

It is possible to dispense with the passing of A over B without affecting the priority of A's movement. This can be done as follows:

Exp. 57. The usual two objects are side by side in the slit, and at the beginning of the experiment they are motionless. Object A moves away from B at a speed of 4 cm. per sec. When it has travelled a distance of 15 to 20 cm., B in its turn begins to move at the same speed and in the same direction. Where the speeds are higher, the distance must be greater.

[8] It seems that the ambiguity of these results arises from the fact that the difference between the original speeds of the objects is too small. Unfortunately it is virtually impossible to make this difference greater, since, because of the double drop in speed, there would be too great a difference between the speeds of object A either side of the impact, and a break in the unity of its movement.

accomplished fact it disappears, and is replaced by some more static impression, such as simple transport.

Our study of the Launching Effect resulted in a similar conclusion, and we may therefore claim that the Launching Effect and the Entraining Effect have the same theoretical basis, that of *ampliation of the movement.*

The temporal priority of the movement of the motor object, which is necessary if there is to be ampliation of the movement, has a double influence on the structural organisation of the whole formed by the two objects. In the first place it brings about or accentuates their segregation, and secondly it sets up a hierarchy in which the entrained object is referred phenomenally to the motor object, even when there is nothing in the configuration to exert any influence in that direction. The result is that the Entraining Effect can appear (as in exp. 2) in conditions in which there would be no Transport Effect even if the temporal priority of the movement of the motor object were absent.

The temporal priority of the movement of the motor object and the similarity of the movements of the two objects after their encounter constitute the essential conditions for the Entraining Effect. It occurs whenever these conditions obtain, and it is independent of the relations existing between the speed of the motor object's movement before the impact and the speed of the two objects' common movement after it (provided the difference between the movements is not great enough to break the continuity of the movement of the motor object, and thus destroy its temporal priority). Whether the speed increases, decreases, or remains the same after the encounter of the two objects, there is always a causal impression, in spite of the paradoxical character which some experiments can display.

Similarly the relative positions of the objects on their path in relation to the direction of the movement is unimportant. When the motor object is behind the entrained object, it gives the impression of gathering it in flight, of carrying it off, or of pushing it, according to the speed conditions; when it is in front, it gives the impression of pulling it, or dragging it along behind.

The appropriation of the movement of the entrained object by the movement of the motor object can develop gradually, and can take the form of a causal impression of acceleration on the part of the second object. In the opposite case, however, when the movement of one object becomes less rapid after its encounter with another object, no causal

SUMMARY NO. 3

Résumé of Chapter IX

One of the fundamental characteristics of the Entraining Effect is the absence of autonomy in the movement performed by the entrained object. This is what we are referring to when we say that it is the movement of object A which displaces B – an expression similar to that which we came to adopt when we examined the Launching Effect. The 'participation' is more obvious in the present case, however, since at the moment when B begins to change its position, object A is still moving.

In this respect the Entraining Effect is genetically related to the simpler case of the Transport Effect, in which the two objects simultaneously perform movements which are alike in direction and speed, while at the same time the transported object participates in the movement of the vehicle.

This participation is made possible in the case of the Transport Effect by a clearly defined structural organisation, resulting in a separation of the systems of spatial reference of the two objects. Since the transporting object forms the immediate frame of reference for the transported object, it is not possible, when both objects are moving in the same way, to receive the impression that the transported object has its own movement; and the movement which it performs in these conditions necessarily becomes merged with that of the vehicle. The transported object seems to be merely 'resting' on an object in motion; and the displacement which it undergoes in this way thus seems to be *purely spatial* and not to possess any real kinematic character, the latter being reserved exclusively for the transporting object.

The Transport Effect, however, in its pure form, does not involve any causal impression. For such an impression to arise it is necessary that the movement of the vehicle should begin *before* that of the transported object.

The causal impression of entraining is thus essentially bound up with the *change which occurs in the already existing movement of the vehicle at the moment when this movement is extended on to the transported object and brings about its change of position*; the causal impression is in fact limited to this process, since as soon as the extension has become an

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CHAPTER X

Launching-by-Expulsion

Launching-by-expulsion is a form of causality which occurs frequently. We meet instances of it when someone throws a stone, shoots with a bow and arrow, slings a catapult, throws a javelin or harpoon, or bowls a cricket-ball.

In some of these cases, however, such as shooting with a bow and arrow and throwing a javelin, the situation is made more complex by the fact that a considerable part is played by another form of causality, viz. propulsion, which we shall be considering in a moment. Other cases, namely those in which the projectile is simply transported by the motor object before the two of them separate, exemplify launching-by-expulsion in a purer form. A good example of the purer variety is to be found when one object gives another a hard shove and then stops abruptly while the second object continues to move by virtue of its inertia.

Launching-by-expulsion differs from launching-by-striking only in its first phase, which instead of approach-impact consists of the Transport Effect. The conditions for its occurrence are very similar to those required for an impression of launching-in-flight, where, as we indicated earlier, object B is itself moving before object A comes into contact with it (see exp. 17, p. 70). A surprising fact emerges, however. In the present case, with the two objects having the same speed before their separation, the causal impression is very clear, while when the speeds are nearly the same in the case of launching-in-flight the causal impression disappears. We must conclude that the Transport Effect is important as such. The reason for this is that as a result of the Transport Effect the movement of the projectile loses its autonomy, and from the very start belongs to the motor object, as it must continue to do during the second phase of the launching.

The theory underlying launching-by-expulsion thus has close affiliations with that which underlies launching-by-striking. In both cases we find inversion of polarity in the movement of the passive object, which seems to *move away* from the motor object, and inertia on the part of the launched object, which appears to be *driven off* by the

impression of braking or deceleration is found. Indeed this is inevitable. The existing hierarchy is one which is necessarily set up as a result of the priority of the movement which leads to the contact of the two objects; and a causal impression of braking presupposes a hierarchy of an opposite kind.

As expected, the causal impression of launching is now quite clear; we see A *launch* B after entraining it for some distance. Moreover the length of this distance influences the result; when it is too large (and exceeds the radius of action) the causal impression disappears, as one might expect. It is scarcely necessary to say that the situation presented in the experiment is one which often occurs in everyday life.

It frequently happens in the case of launching-by-expulsion that the *projectile is hidden by the motor object before separating from it.* This occurs, for example, when we see someone throwing a pebble which has been in his hand, or using a catapult. In such circumstances, however, we still receive an unmistakable causal impression. Since this seems in direct contradiction with what was said earlier in the book, we carried out several experiments to investigate the matter further. The requisite conditions were easy to achieve.

Exp. 61. This is the same as exp. 1, except that object *B* is not present at its starting-point. A begins to move at a speed of 30 cm. per sec., and stops at its usual place. At this moment B appears *already moving* beside A, and travels at the same speed to its ordinary stopping position.

This experiment (mentioned on p. 46, note 6) was carried out with forty-one new subjects. If we ignore three doubtful cases, the results are as follows: seventeen of them (42%) received a causal impression of launching; to all the others B's movement appeared autonomous.

The same experiment was then repeated many times with the very experienced observer Mi., and the intervals between the stopping of A and the appearance of B were varied. His observations confirmed and added to the previous findings. The causal impression of launching appeared in 27% of the total number of observations (120), and conditions seemed to be more favourable to it when the intervals were of medium length (about 15 to 100 milliseconds).[3]

[3] The autonomy of B's movement takes a very remarkable form in this experiment. There were some cases in which the impression received by the subjects merely reproduced the objective situation, but there were others in which B's movement was seen as beginning *before B itself appeared.* (This was so for 27% of the new subjects and for 53% of the thirty observations made by Mi. when the intervals were 14, 28, and 42 milliseconds.) In these cases object B seemed to 'come out of' object A (without being actively thrown out of it), or to emerge from the same place as A after being concealed by it for part of the way. These results link up with those mentioned earlier (see Chapter III); like them they bring out the fact that phases of movement, if they are not limited by a stage when the object is motionless, have an uncompleted look about

first object. These points have been discussed in detail in the preceding chapters, and we need not return to them now.

When we try to produce launching-by-expulsion experimentally, using our ordinary methods, we run up against the difficulty which is inherent in any attempt to produce a pure Transport Effect.[1] Thus although it seems at first sight as if the following experiment ought to produce a good example of expulsion, the results are negative.

Exp. 59. The two objects A and B are side by side, and start to move simultaneously at the same speed. After they have travelled a distance of 4 or 5 cm., A stops abruptly while B goes on moving, still at the same speed, say, 40 cm. per sec., for another few cm. This experiment is the simple converse of the second Type-experiment, and can be carried out by the disc method by rotating the discs in the opposite direction.

There is no trace of a causal impression in these conditions. A group of two objects or a bi-coloured rectangular block is seen moving along; at a given moment part of this becomes detached from the rest and continues the movement which it was previously making *qua* constituent of the group or block. The movement of B is entirely autonomous after the separation from A; it in no way belongs to the part of the block which has stopped, any more than it did before the separation. The conditions of structural organisation are of a kind to make the two objects of equal status,[2] and when they are united into a whole there is no hierarchisation to affect the appearance of the movement.

If a slight change is made in the experiment, however, a causal impression can be produced. The conditions have to be arranged in such a way that the two objects remain distinct during the first phase, and so that the movement belongs to object A. This happens, of course, in the Type-experiment of entraining (exp. 2); we need therefore only combine exp. 2 with exp. 59 to obtain the desired result.

Exp. 60. The two objects are placed 4 or 5 cm. apart. Object A begins to move at a speed of 15 to 20 cm. per sec. and goes towards B, which is motionless at the centre. At the moment when it reaches B, B in its turn begins to move at the same speed, and the two objects travel joined together, as in the case of entraining. After they have travelled 3 or 4 cm. together, A stops abruptly while B continues to move at the same speed as before.

[1] See Chapter IX, 2, p. 152. It is possible, of course, in this case to use a device similar to that described in connexion with exp. 51.

[2] The same thing happens in launching-in-flight experiments in cases where the two speeds are approximately equal.

whether a causal impression did or did not appear. Now obviously, if it appears *when the experiment is carried* out *stroboscopically*, *a fortiori* it must do so when the movements are really continuous. A negative result would, of course, be much more difficult to interpret.

Exp. 62. This experiment was carried out by means of a 'comparison-tachistoscope', an instrument fitted with a set of mirrors which enable the observer to see at the same point objects which are in fact located in different places.[4]

The apparatus had been adapted so that each object could be shown for whatever length of time was needed, the second being abruptly substituted for the first after previous warning. The substitution occurred after the observer had fixated the first object for several seconds. It was also possible to alternate the order of presentation, by first putting object B in place of object A, and then putting object A in place of object B, and so on. This was done at a rate involving an interval of 0·55 of a second between two successive substitutions.

The objects had a maximum height of 40 mm.; they were drawn on square pieces of cardboard of side 10 cm., which were 42 cm. away from the observer's eye.

The substitution of one image for another was made by means of two shutters. One shutter moved progressively in a vertical direction, and in so doing covered the first image, while the other shutter, moving at the same speed, disclosed the corresponding part of the second image. The linear speed of the screens in relation to the plane of the objects was 200 cm. per sec., and as a result the length of time taken for the whole substitution was about 20 milliseconds. In these conditions the movement of the shutters passes completely unnoticed, and we simply receive an impression of the objects moving. There is no difficulty in arranging still greater speeds for the shutters, but this has no effect on the results of the experiment.

The objects used are shown below (Fig. 7). There are six pairs of diagrams drawn there, each indicated by means of a letter. For each pair the numbers 1 and 2 indicate the order in which they are shown; the position of each drawing, in relation to the centre of the frame which surrounds it, corresponds to the position which it occupied in relation to the centre of the visual field in the experiments.

Pairs A and B are schematic representations of javelin-throwing. The vertical line and the slanting line which accompanies it correspond respectively to the body and arm of the athlete.

Pair C represents the same thing with the body left out.

The three following pairs represent shooting with a bow and arrow. The bow and arrow are indicated more or less in full in pair D and schematically in pair E, where only the 'bowstring' and the 'arrow' are

[4] A. MICHOTTE, Description et fonctionnement d'un nouveau tachistoscope de comparaison, *Arch. de Psychol.*, XII, 45, 1912.

There is thus considerable variation in the results of this experiment. The movement of object B can look as if it is produced by object A, or it can appear autonomous. The fact that the causal impression occurs at all shows, as we have already seen, that a phase of immobilisation of one of the objects at the centre creates conditions sufficiently favourable for segregating the movements. Moreover, since in other respects the total conditions are very similar to those of the Type-experiment of Launching, it is not very surprising that the causal impression is found to appear some of the time. What is surprising is that this impression appears here but does not do so in the case of exp. 59, where both objects are present before they separate. A comparison between the two experiments points to the conclusion that the presence of object B at the start, as part of a moving whole, favours the maintenance of autonomy in B's movement after the separation.

In some cases the Launching Effect occurs, not after a mere transport or entraining, but after what is in fact a *propulsion*. To understand these, however, it would be necessary to study propulsion first. For the moment I shall simply mention the experimental method which we adopted in order to confirm that a causal impression could occur, and I shall then describe the results obtained from our examination of launching-by-expulsion.

The method which we chose made possible a wide variety of experiments and was entirely adequate for our purpose. We applied the stroboscopic method to 'animated drawings' of various degrees of complexity. The first drawing showed the two objects touching one another, just as they are at the beginning of the Launching Effect. A second drawing, which was suddenly substituted for the first, showed them after they had separated.

It is tempting to criticise the use of this somewhat artificial method, and to regard the presentation of objectively continuous movements as preferable. Such procedure, however, would give rise to considerable practical difficulties; and, quite apart from that, the question seemed to us of minor interest, since all that we wanted to know was simply

them, and a tendency to become completed, as happens in this case when there is an apparent continuation of the movement from something happening beforehand.

What is involved here is a phenomenon analogous to that of the well-known influence of contour in the sphere of static perceptions. The phase of an object's immobilisation seems to play a similar part in the sphere of movement.

shown. In pair F only half the bowstring is shown, and the result is simply two lines forming an angle.

This kind of experiment is not always equally successful, nor does it work as well with some observers as with others, some of them seeing only a substitution of one image for another. In the majority of cases, however, the results are positive. Another difficulty is that the causal impression does not always appear at the first presentation, and it is sometimes necessary to perform the experiment several times before it is fully apparent. This is particularly true of drawings which have a very much simplified form, especially pair F. It is easy to see why this is so. The causal impression, as we have found, corresponds to a fixed structural organisation, and one of the most important conditions for its appearance is that the objects should be phenomenally distinct when the movement begins. Now, when our experiments were in their early stages we used a drawing in which the objects were shown *touching one another*, and we found that they could be seen as a total configuration, so that they lost their individuality. To avoid this difficulty we used objects of different colours, and gave the arrow a point and sometimes feathers as well. For the same reason the 'bowstring' was made a different thickness from that of the 'arrow', and one of the lines in pairs C and F was made thicker at both ends.

Even without these precautions, however, a perfect causal impression is sometimes possible; usually it needs only a few repetitions to bring about an automatic segregation of the objects. In such cases *the result is entirely conclusive*; we see the arm *launch* the javelin (pair B is a really striking example of this) and the bowstring *launch* the arrow. Indeed the causal impression is so strong that observers are quite astonished to see the javelin and the arrow stop in mid-air after the launching and remain motionless.[5]

[5] When the diagrams are shown in the opposite order, it is possible to have the impression that the javelin rejoins the arm and carries it back, or that the arrow goes and pulls the bow! In these conditions, however, the causal impression is less clear, for reasons which I shall give later.

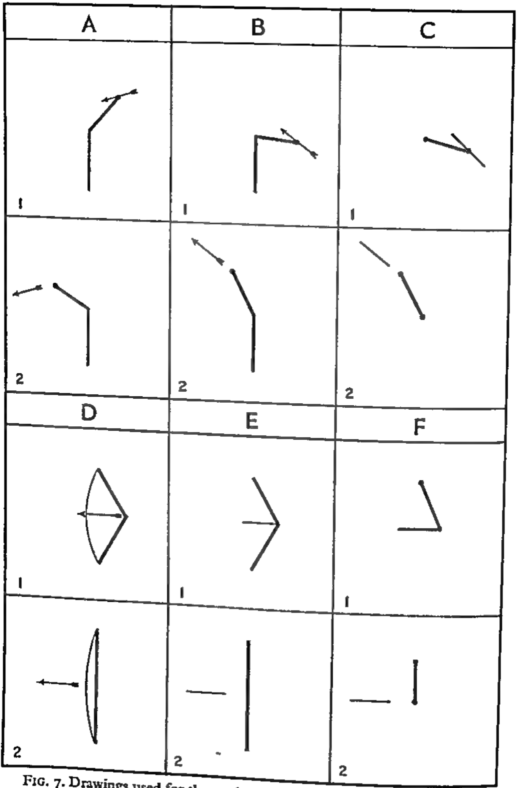

FIG. 7. Drawings used for the stroboscopic demonstration of launching-by-expulsion

a causal impression in simplified experimental conditions reminiscent of the examples just quoted.

Once again we had recourse to the stroboscopic method, which seemed most likely to provide useful indications.

Exp. 63. This experiment was carried out by means of the stroboscopic method described under exp. 62. The patterns used are shown in Fig. 8. The diagrams labelled 2 are different from those of Fig. 7 in that the objects have not yet separated, but are in the position in which they should be at the moment when they separate.

Pairs A, B, and C correspond to A, B, and C in Fig 7, and pair D corresponds to pair E. Pairs E and F correspond to pairs E and F in Fig. 7, except that the 'bowstring' moves farther in Fig. 8 and reaches a position symmetrical with that which it had when it started to move.

Although the same reservations apply as were made in connexion with exp. 62, the causal impression can quite well appear in all these examples, and it is as immediate and as much a basic given as it is in the Launching and Entraining Effects. It is the arm or the bowstring which *makes* the object move; the bowstring *makes* the arrow fly (this is particularly noticeable in pair E), and the arm *makes* the javelin travel through the air. The dynamic effect in these experiments is quite remarkable, and this time we are surprised when we do not see the arrow or javelin separate from the motor object; the action appears unfinished and it seems that the arrow and the javelin 'ought' to go farther!

It follows that there must be another organising factor here, which we have not met before, which has the effect of reconciling the occurrence of a causal impression with the simultaneous beginning of the two movements. It is this point which requires further examination.

With this problem in mind let us examine one of the examples quoted, that of the arrow in pair D, Fig. 8.

It is logical to apply here the information obtained from our study of other forms of causality. In particular we are justified in saying that the existence of a causal impression implies that there is *participation* by the arrow in the movement of the bowstring, or, to be more exact, that there is an *extension* on to the arrow of the movement of the bowstring. In this case, however, such an extension can occur only in a very different form from that found in our earlier examples. There is in fact a difference in kind between these two movements which might be expected to keep them quite unrelated to each other, for while the arrow merely undergoes a simple *downward movement*, the bowstring *changes*

CHAPTER XI

Propulsion

Some cases of launching-by-expulsion, particularly the bow and arrow, harpoon, and javelin examples, interesting as they are in connexion with launching, are of still more interest from the point of view of entraining. Indeed, as far as the latter is concerned they open up entirely new lines of thought and make possible a striking development in our application of the idea of ampliation. There seems no doubt that in such cases there is a causal impression from the very first phase of the operation, i.e. before the projectile separates from the motor object – an impression which occurs despite the fact that the movements of the two objects *begin simultaneously*.

As soon as the bowstring begins to slacken, it sets the arrow in motion; as soon as the arm begins to move, it throws the javelin forward. I shall call this form of mechanical causality *propulsion*. There are innumerable cases in everyday life in which similar conditions arise and in which a clear impression of causality is given. This is true of most of the cases in which tools or other instruments are used, e.g. a pen, a brush, a rake, a hammer, or a violin bow. We undoubtedly receive the impression that it is the hand or arm of the person which *makes* these objects move. Yet here too the movements of the arm and the tool often begin simultaneously.

Now to judge from our conclusions so far there ought not to be a causal impression in such cases, but at the most a Transport Effect, since our own earlier experiments showed that the causal impression is bound up with the temporal priority of the movement of the motor object (Chapter IX, pp. 153 seq.). Moreover it was this temporal priority which provided the basis for our fundamental concept of ampliation of the movement, and doubt thus seems to be cast on our whole theory.

The question might be raised, of course, as to whether in the examples quoted there is a causal impression at all, or merely a very rapid interpretation, which arises because of the complexity of these cases and the fact that they are concerned with human movement. We were therefore anxious to check on this point and see whether it was possible to produce

its shape and straightens up, undergoing a transformation similar to that of the curve in exp. 46 (Chapter VIII, p. 130).

It is true that from a geometrical point of view this straightening up consists of a horizontal displacement of the apex of the angle; but this displacement, which is combined with a change in the orientation of the sides, does not seem at all like a change in position of the bowstring, especially since the ends of the bowstring remain fixed. Instead the impression which one receives is that of a 'flattening out' of the angle towards the left, and this is clearly a change of a qualitative kind. Moreover this flattening out is only one aspect of the total operation of 'straightening up'.

It is obvious that in these conditions there can be no question of the movement of the arrow participating in the movement of the bowstring *as such*. We have here the reverse of what happened in the cases of transport and simple entraining, and even in the case of launching, where the movement of the passive object can become identified with that of the motor object. In this case, by contrast, the coincidence is only a partial one, viz. between the forward movement of the passive object and one aspect of the change in shape of the active object.

This point has important consequences. Since the alteration in the active object in fact consists of a change in shape, this change comes about by the object passing through a series of successive stages, each one qualitatively different from the next; and its specific character, that of the flattening out of the angle, results at each instant from the course which the evolution takes. It follows that the participation by the arrow in the 'movement' of the bowstring must take place *at each moment, as a result of stages which are qualitatively different; it must thus be continually renewed as the metamorphosis of the active object progresses.*

If this is true, we see immediately why the causal impression is in this case compatible with the simultaneous beginning of the two 'movements'. Adopting the standpoint on the subject of causality which our research demands, we may say that temporal priority is no longer required because the extension of the 'movement' of the active object on to the passive object *is made afresh* at each moment in the operation. Thus a *continuous ampliation* takes place; and in this way it seems possible in the last analysis to consider propulsion as *an entraining which is constantly being renewed* during the whole time in which the active object is changing shape. This is the reason why the causal impression can be maintained indefinitely in such cases (e.g. when tools are being

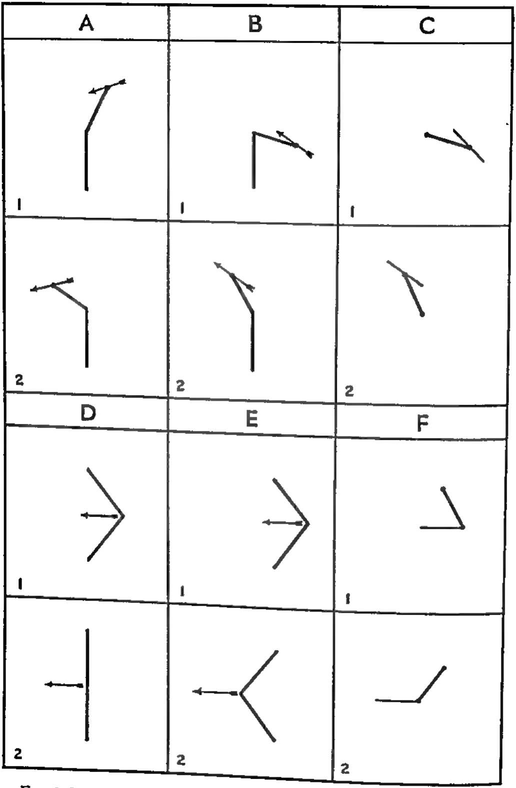

FIG. 8. Drawings used for the stroboscopic demonstration of propulsion.

very interesting research. It is certain that there must be an optimum proportion of difference and coincidence, and that the highest degree of coincidence compatible with a clear qualitative difference will necessarily favour the causal impression. Thus in Fig. 8 the causal impression seems to be appreciably better in the case of pair E, for example, than in that of pair D. Now it is clear that the character of being horizontally displaced which the apex of the angle possesses is much more accentuated in the former case than in the latter, and a much more complete identification with the forward movement of the arrow is thus possible.

All this, however, does not explain the direction in which causality seems to work in these cases, since in the absence of a succession of movements, it is equally possible *a priori* that it should operate either way. Why does the movement of the bowstring move the arrow? Why does not the arrow pull the bowstring? We were faced with a similar problem previously in connexion with expts. 48 and 49 on entraining (pp. 149–50), and we came to the conclusion that it must be a question of dominance and centres of reference. Undoubtedly the same applies in this case, and provisionally at least we can assume that it is the higher order of movement (qualitative change, rotation, etc.) which dominates the mere forward movement and seems to 'produce' it. I shall return to the problem of centres of reference in a moment.

In the example just discussed, it was the change in shape of one object which seemed to cause the forward movement of another. (I shall call this 'propulsion type I'). It often happens, however, that a change in shape seems itself to be brought about either by a forward movement or by a change in shape of another object. (I shall call this 'propulsion type II'.)[2] This occurs, for example, when we bend a blade of grass by bringing the ends together, extend or compress a coil spring, squash a cushion with our hands, or squeeze an orange or a rubber ball.

One way of producing cases of this kind would be simply to reverse the order of presentation of the drawings used in the stroboscopic experiments (see Fig. 8); indeed this is sometimes successful, although more often it is not. A causal impression is obtained much more readily

[2] In my earlier enquiry I gave the name 'conformation' to the case where the active object brought about a change in the shape of the passive object (A. MICHOTTE, La causalité physique, op. cit., p. 315), and thought it necessary to give it a separate status along with launching and entraining. As a result of the way in which our research has developed I have decided to include these phenomena under the wider heading of 'propulsion' and link them up with the Entraining Effect.

handled), without degenerating into a simple Transport Effect, although entraining in the strict sense lasts, as we know, only for a short time.

In the other examples which I have given there is also a qualitative difference between the movement of the motor object and that of the projectile. Thus in Fig. 8, examples A, B, C, and F, the motor object performs a rotation round an axis passing through one of its extremities. In this case it is the *rotation* of the motor object which is transformed into the *forward movement* of the passive object.

This theory enables us, I think, to reconcile the occurrence of the causal impression and the simultaneous beginning of the two 'movements'. It also has the merit of linking up propulsion with other forms of the causal impression, and does not involve any departure from the general principles which have so far proved fruitful.

It follows, from all that has gone before, that propulsion is the outcome of a somewhat complex system of conditions. What is required, as in the other forms of causality, is that the general conditions making for integration of the two movements should be satisfied, and the further conditions which ensure their being kept distinct; but, in addition to this, these 'movements' need to be different in kind and yet in some respects to coincide.

The necessity for them to be different in kind is amply shown by the fact that the causal impression is absent in the case of the simple Transport Effect, while it is present, *ceteris paribus*, where this difference in kind occurs.

A very interesting counter-proof of this can be obtained if we change drawing No. 2 in each pair A, B, and C of Fig. 8 so that the javelin is now *in the same relative position* in relation to the arm as in the corresponding drawing No. 1. The movement of the javelin is then similar to that of the arm, and apparently performs a rotation round the axis of the latter. The causal impression does not appear in these conditions; instead we find either the Transport Effect when the two objects remain distinct, or a rotatory movement performed by a complex object.[1]

The question of the degree to which the two movements have to coincide if the causal impression is to arise would be a subject for some

[1] It should be noted, however, that when this experiment is performed by the stroboscopic method, it is necessary to avoid giving the javelin too large a rotation as a result of the arm movement, for such a rotation can easily appear as a movement of the javelin itself in relation to the whole framework.

B by pushing it. In these conditions the causal impression can be extremely good.

These cases are to a large extent different from those coming under the head of propulsion Type I. Here it is the forward movement of the motor object which brings about the change in shape of the passive object. Now, as was pointed out a moment ago, the two 'movements' are similar only to a very limited extent; the change in shape coincides with the forward movement in one aspect only, while in other aspects, and in particular as regards its specific character, it has nothing in common with this movement. It therefore seems as if the change in shape *as such* cannot really be part of the causal impression. This conclusion receives further support from the following considerations.

When studying the Entraining Effect we saw that the motor object had to be regarded as the centre of reference for the entrained object, that it was for this reason that the entrained object gave the impression of being inert, and that the displacement appeared ultimately to be brought about by the movement of the motor object.[4]

Now when a change in shape of either or both objects is involved, the situation seems different, since, as has been indicated on several occasions, the impression of a change in shape, like that of growing or shrinking, implies that the movement performed by one part of the object is referred *to another part of the same object.*

We may ask ourselves how in these circumstances a change in shape can play any part at all in the perception of causality, let alone the part of effect in cases where the passive object undergoes the change. In other words, how can the change in shape of object B seem to be brought about by the movement of an external object (object A), if object B's centre of reference is not object A at all?

This difficulty is a real one; indeed in expts. 22 and 23 (Chapter IV, 4, pp. 74 and 75), we were able to destroy the Launching Effect by substituting a contraction of object B for a forward movement.

Moreover, if we study carefully the cases of propulsion which we are now considering, it is easy to see that the passive object in no way gives the impression of being inert, as it does in the cases of the Transport and Entraining Effects. The change in shape clearly *belongs* to the passive object, and is *owned* by it. Exp. 64 shows this clearly, as do the simplest everyday happenings. To convince ourselves of this we need only make a slight dent in the surface of a rubber ball or cushion, using a pencil-

[4] Chapter IX, 2, pp. 150 seq.

when a change in shape is followed by a forward movement than when a forward movement is followed by a change in shape; and when the images are produced alternately at intervals, a causal impression in the first direction is what usually forces itself upon us. When the drawings of Fig. 7 are used, the results are better; the impression is then given that the arrow, the javelin, etc., perform an approach movement before they reach the other object or produce any change in its shape. In this case there is temporal priority of the forward movement, and the dominance which results from it has a clear influence on the appearance of the causal impression. We took advantage of this factor of temporal priority in the following experiment, which was carried out by the disc method. Here the phenomenon can be observed in well-defined conditions.[3]

Exp. 64. This is a modification of exp. 2. The two objects are longer than usual – 10 or 15 mm. – and the observations are made from a short distance away (50 cm.) so as to make perception of the shape easier.

The disc is made in such a way that the curves corresponding to the movements of the objects (see the section on calibrating the discs, Chapter II, p. 28) have an extra steep 'slope', 0·25 cm. per degree, for instance. This means that when the objects are moving along the slit, they are shaped like parallelograms, or more strictly like rhombi lying on one side. The speed has to be very much reduced and should be no more than 3 or 4 cm. per sec.

A shutter is fitted to the slit in such a way as to hide object A during its initial phase of immobilisation. As a result we see it appear as a rhombus moving towards object B, which is a rectangular motionless shape. At the moment when object A reaches object B and afterwards as it advances, B gradually changes shape and becomes a rhombus also. (This corresponds to B's starting to move in the earlier experiments.) An extra attachment enables us to stop the movement of the disc as soon as B has completed its change in shape and before it begins its forward movement.

Operating in these conditions, we have the impression that when the apex of the rhombus A touches the rectangle B, it changes the shape of

[3] It is often extremely difficult to produce impressions of this kind by our usual methods. This is particularly true if we make the passive object change its shape (as it moves away from the place of its encounter with the motor object) by becoming progressively smaller as the motor object moves forward. We did an experiment along these lines to see whether it would produce a causal impression of 'compression'. There is in fact no such thing, and we simply see the moving object *cover* the other (Screen Effect). This is an interesting case of phenomenal permanence. (See A. C. SAMPAIO, op. cit., p. 23.)

the impression of *change in shape of the whole* appears, that this pressure evolves into a propulsion; and doubtless the same would apply in the cases of the pencil and the ball. When the operation is performed at normal speed, however, the fact that one follows the other is not really apparent, any more than is a difference between the particular part of the passive object where contact takes place and the object as a whole. What we see is a *change in shape of the passive object under the influence of the motor object.*

Once again, as in the case of the Triggering Effect mentioned just now, there is autonomy but not spontaneity – this time in the change in shape of the passive object. It seems, too, that the degree to which the change in shape is dependent on the pressure must vary with the extent of the area of contact. In particular, it is probable that a large-scale change in shape will seem more spontaneous when there is pressure on a very small area than when the pressure extends over a larger one, as it does e.g. in the case of the ball or the orange being squeezed in the hand, to quote our earlier examples.

We can also understand from all that has been said why the temporal priority of the motor movement is required when a simple forward movement produces a change in shape; it is because the conditions for the Entraining Effect have to be set up, and the forward movement has to be dominant. Conversely, when it is a question of a propulsion in which the two movements consist of changes in shape (e.g. squeezing a ball in the hand), it is possible that the dominance of the movement of the motor object may be ensured by other factors, such as the inclusion of the passive object inside it.

In short, all cases of propulsion seem to stem from one and the same basic theory. To use our earlier formulation we may say that they all seem to bring about an entraining which is being renewed at each moment. Thus the Propulsion Effect is linked with the following conditions: *the parts of the active object and of the passive object which are in contact must perform movements which are similar in speed, direction and extent (as in simple entraining); the movements of these parts of the two objects must each be integrated in movements different in kind, and the total movement of the motor object must be dominant over that of the object moved.*

One final point requires mention. The cases of launching-by-expulsion to which we referred in the previous chapter (in which the first

point. In this case it is the actual mass which changes its shape, and the change in shape belongs to the object beyond any possible doubt.

Thus the change in shape has a degree of autonomy, and this fully confirms what we said just now on the theoretical side. It remains true, however, that this change in shape appears to occur as a result of the active object's intervention, and seems to be brought about by the active object.

These different characters are not so irreconcilable as one might suppose them to be at first sight. Indeed we have actually met a similar case earlier in the book – that of the Triggering Effect. Here, as we said, the movement of object B is autonomous without being spontaneous; it is independent of the movement of the active object in its execution, but remains dependent on it for its origin (Chapter VIII, 2, pp. 144 seq.).

To obtain an accurate account of what is involved in the present case, our best way will be to examine the simplest possible example. Let us therefore consider what happens when the stroboscopic experiment with the diagram of Fig. 7, group E (p. 170), is carried out the other way round.

In these conditions one can sometimes receive the impression that the arrow changes the shape of the bowstring by pushing its centre. This is what might be expected. Indeed, if the bowstring were reduced to its central part where it is in contact with the arrow, this part would be found to fulfil the conditions required for the production of the Entraining Effect, and its movement would be identified with that of the arrow. On the other hand, if we suppressed the arrow, the different parts of the bowstring would be displaced in relation to one another, and there would merely be a change in shape. The centre of the bowstring, however, is not isolated from the rest; together they form part of the same whole, and as a result the movements which they perform simultaneously must likewise be integrated in a single comprehensive operation. This is in fact what happens. The change in shape of the bowstring, while keeping its own character, also appears as a 'development' of the entraining; it thus participates in the causal character of the latter in such a way that the change in shape seems actually produced by the encounter of the bowstring with the arrow. Moreover, when exp. 64 is performed extremely slowly, the first impression received is simply one of pressure exerted by the motor object on that part of the rectangle with which it comes into contact. It is only secondarily, when

CHAPTER XII

Animal Locomotion

Among the examples of causality mentioned in the last two chapters, several, it will have been noticed, were concerned with human activity. This is no accident. Situations in which mechanical causality can actually be perceived in the world of inanimate nature are in fact very rare (except in the case of machines made by man). Causality is usually to be found in conditions in which either the cause or the effect go unobserved. For example, when a body falls or a river flows, the compelling force is that of gravity; when the leaves of a tree are shaken, when clouds are driven across the sky, or when a door is blown shut, it is the wind which is operative. There are, of course, examples where this does not hold, e.g. a branch falling and breaking another branch, or the waves dragging at shellfish on the rocks and carrying them away; but cases of this sort are by no means easy to find.

As soon as we consider human or animal activity, on the other hand, examples of causality are extremely numerous. They are found not only in the case of our own activity, and that of people round us, but also when man-made tools operate to produce changes in objects. To convince ourselves of this we need only watch someone engaged in some piece of work. We see that all the time his hands are pushing and pulling, lifting objects, putting them down, or striking them. It is amazing, too, to find how these causal forms appear and combine in different activities – at meals, for example, in sewing, or even when someone handles a book while reading it. All this is easy to understand if we consider that the infinite varieties of human behaviour form two principal groups, viz. manipulation and expression by gesture (including language), and that manipulation itself is the perceptible mechanical antecedent of all changes which it brings about in objects. Thus we can say that in the great majority of cases where we observe causality in everyday life, human movements intervene (and to a lesser degree animal movements).

This, however, is not the whole story. Besides their relations with external objects, the movements made by a man or an animal possess a special character which, in the normal way, differentiates them clearly from the movements of inanimate objects, and makes it easy to recognise

phase consists of a propulsion) do not appear to present any difficulties of interpretation. The fact that the object has been 'released' does not in any way break the continuity of its movement; consequently the causal character of the operation comes from the actual propulsion as such. I need hardly add that, if that is so, this type of launching must be considered as being somewhat different from other types, and as having theoretical affiliations not so much with launching as with entraining.

In the second phase, the rectangle contracts from the left, at the same speed, until it has returned to its original length of 10 mm. This time the T end has moved to the right while the H end has remained still. At the end of the whole period the original rectangle has thus moved 32 mm. Then the same cycle begins again, and is repeated three or four times until the object has moved the whole length of the slit.

It is quite in order to introduce intervals of several hundredths of a second (perhaps 3 or 4) during which the figure is completely at rest. This may be done either after each phase or after each period.[1]

Exp. 66. This second experiment is very similar to the first, the only difference being that the two ends H and T move at different speeds. The original length of the rectangle is 12 mm.

During the first phase, the rectangle extends towards the right at a speed of 6·6 cm. per sec., until it reaches a total length of 39 mm., while the T end remains still.

In the second phase, the rectangle contracts from the left at a speed of 2·2 cm. per sec. until it returns to its original length, while the H end remains still. Thus the second phase lasts three times as long as the first.

The total distance that the object has moved at the end of the period is 27 mm.

These experiments are amusing to try on subjects who are being tested for the first time. After they have watched for a moment what is happening in the slit on the apparatus, they generally show great surprise and without any prompting they say 'Caterpillar!' or 'Worm!' Indeed the impression of animal locomotion is startling; one literally sees an animal crawling or creeping, and it is genuinely an object *which moves of its own accord.*

In addition, we can discover a remarkable internal structure in the object in the form of a very clear differentiation of function between 'head' and 'tail'. The locomotor function seems to be located in the region of the 'head'; it is the head which *advances* when the animal expands, while the contraction which follows seems to consist of a simple

[1] As the disc for this experiment requires special patterns, some further information on the subject may perhaps be helpful.

The original rectangle is obtained by drawing on the disc the arc of a circle, 10 mm. thick and covering an angle of 40 degrees. Next the inner side of the arc is made to approach the centre with a slope of 0·08 cm. per degree for 40 degrees, while the outer side is a continuation of the arc as before. Next it is the outer side which is made to approach the centre; it does so at the same slope, over a distance of 40 degrees, while the inner side takes the form of an arc of a circle, and so on.

The rotation-time of the disc was between 5 and 13 seconds.

the presence of animal life, an important fact from the biological point of view. These movements are not only spontaneous, like those of inert objects which begin to move without external cause, but they also have the appearance of being activities of which the object itself seems to be *the source*. Thus when observers describe what they see in simple language, they say without exception that they see an object which 'is moving of its own accord', or 'is going under its own steam'.

This impression is in fact very different from the causal impression with which we have been engaged up to now, and one might think at first that there are no grounds for spending time on it in this book. A moment's reflection, however, shows that the question requires very close examination. The expressions used spontaneously by observers amount in effect to an assertion that the animal itself *is producing* the movements which it performs, and this implies a causal relation. In that case we are justified in asking ourselves *what, in the phenomenal aspect of the experience*, leads to such an assertion, and whether there do not exist closer relations than we might suppose between perception of living movements and perception of causality.

It should be added at once that the problem of living movements is too vast to be treated with any degree of completeness in this book, all the more because it is closely connected with the wider questions of phenomenal metamorphosis and activity. I shall content myself with indicating here the points which seem to me most essential for our present research, and the actual investigation will be limited to the case of animal locomotion.

We have tried to reproduce this phenomenon systematically under controlled experimental conditions. We began by observing the movement of caterpillars, and after that we produced schematically, in as simple a form as possible, movements similar to those performed by a number of such animals. Here are two examples of experiments along these lines.

Exp. 65. A single object is present, consisting of a rectangle 10 mm. long which is placed at the extreme left of the slit in the screen. In order to make the description of the experiment easier, I shall call the right-hand end of this rectangle H (head) and the left-hand end T (tail).

The experiment consists of a series of cycles each of which is divided into two phases.

During the first phase, the rectangle extends towards the right at a speed of 2 to 6 cm. per sec. until it reaches a total length of 42 mm. The H end has then moved 32 mm. while the T end has remained still.

In the second phase the H end continues to move towards the right at a reduced speed of 1·1 cm. per sec., while the T end, reversing its original direction of movement, also moves towards the right, at a speed of 4·4 cm. per sec. Thus it gradually gets nearer to H, and this continues until the rectangle has returned to its original length of 10 mm. The duration of the second phase is about two and half times as long as that of the first.

At the end of the complete period, the rectangle has moved 30 mm. to the right.[3]

The character of 'being alive' is quite as evident in this experiment as in the case of the 'caterpillar' experiment, but instead of crawling movements, this time there are *swimming* movements. The object is seen swimming in a fairly viscous medium, in which it moves forward with backward thrusts of its tail behind! It is the tail in effect which provides the movement while the head seems inert; the head is pushed forward by the tail and does not actively take part in the forward movement. Moreover the fact of its inertia can be confirmed if a slight variation is introduced into the experiment, that of cutting the object into two parts, viz. two squares, side 5 mm., of different colours, and arranging them in such a way that only the square corresponding to the tail changes size, while the head remains the same all the time. In these conditions the impression obtained is nevertheless in all respects similar to that given by exp. 67.[4] This brings out strikingly the analogy between this kind of auto-locomotion and propulsion Type I; in short, the tail is here playing the part of the bowstring while the head plays that of the arrow! The only difference that there seems to be between the two cases (and we shall see that it is an all-important one) is that the head and tail are constitutive parts of one and the same object. It is scarcely necessary to point out that this kind of forward movement is extremely common

[3] The pattern on the disc is so designed that, for the first phase, the outer side of the original arc *moves away from* the centre with a slope of 0·06 cm. per degree for 30 degrees, while the inner side *approaches* the centre with the same slope also for 30 degrees. For the second phase, the two sides *approach* the centre for 80 degrees, the outer side with a slope of 0·06 cm. per degree, the inner side with a slope of 0·015 cm. per degree. The rotation-time of the disc was about 5 seconds.

[4] It is important to note that in spite of this the dilatation of the tail must be bilateral if the Swimming Effect is to appear. When the dilatation which occurs in the first phase takes place only towards the rear of the object, all impression of auto-locomotion disappears. In this case what is seen in the first phase of each cycle is a motionless object which expands towards the rear; and in the second phase the object is seen to advance at the same time as it contracts. Neither the dilatation nor the contraction take any part in the forward movement, which is made in the same way as that of an inert object.

pulling in of the tail, which merely moves nearer to the head and does not seem to be taking any part in the forward movement![2]

In short, this experiment produces an impression radically different from that which we get when we see an inert object begin to move, as did object A in our launching and entraining experiments. Indeed it could hardly be otherwise; for the autonomous movement of the 'caterpillar' is a much more complex operation, which includes, besides the overall movement of the object, alternate dilatations and contractions *which clearly play a part in the advance of the whole.*

We shall later have to reconsider in detail the importance of this difference (and the part played by the changes in shape) from the phenomenal point of view. But the very fact that we have been able to establish it right at the start suggests immediately that there is some relationship between auto-locomotion and the Type I Propulsion Effect, in which a change in shape likewise marks the beginning of a forward movement. This relationship shows up even more clearly in another type of animal locomotion, which was found to occur during experiments whose object was to accentuate the segregation of the two kinds of movement. The result obtained was not at all what was expected, but in fact turned out to be very much more interesting. Here is a description of one of these experiments.

Exp. 67. The object consists of a rectangle 10 mm. long which is about 25 mm. from the left-hand end of the slit.

The experiment comprises a series of cycles each of which is divided into two phases.

During the first phase the rectangle expands symmetrically, the two ends H and T moving away from each other, each at a speed of 4·4 cm. per sec., until the object reaches a total length of 46 mm.

[2] Although the change in position of the 'tail' does not *seem* to play any part in the forward movement, it nevertheless is indispensable for the creation of this movement. This can be shown by an experiment in which the T end of the object is completely immobilised, while its H end advances in jerks in the same way as in exp. 65. In this case there is simply the impression of a series of unilateral 'lengthenings' or dilatations of the object, but the impression of moving forward is entirely absent *in spite of the fact that the centre of gravity of the object is advancing* at each new expansion. The displacement of the extreme end of the physical object in exp. 65 is the necessary condition (i) for the impression of the tail being pulled in, and (ii) for the impression of forward movement. (The reason for this will be seen in a moment.) In other words these two phenomenal features are linked with the same system of stimulus-conditions, but that in no way implies the existence of a phenomenal connexion between the features themselves.

angle extends towards the right, either at the very slow speed of 0·64 cm. per sec. or at the much more rapid one of 14·4 cm. per sec., until it reaches a total length of 32 mm. The H end has then moved 16 mm., while the T end has remained still.

In the second phase the rectangle contracts from the left, at the same speed, until it has returned to its original length of 16 mm. It is thus the T end which has moved this time, while the H end has remained still.

At the end of the whole period, the rectangle has moved 16 mm. to the right, and remains still for the rest of the time.

This test was tried on thirty-two new subjects. Sixteen of them began with the experiment at the slow speed, and continued with the fast speed only after an interval in which they took part in tests of a completely different type. In the case of the other half of the subjects the tests were given the other way round.

When the speed was slow, twenty-eight subjects (87·5%) received the impression of dilatation and contraction of the object, while only three mentioned its displacement. Similarly, there were only three who said that they had an impression of live movement (i.e. caterpillar movement).

In the case of the fast speed, there were very different results. Thirty subjects (93·7%) described what they experienced as a displacement of the object, a movement in two stages, as some called it; but this time only ten mentioned the change in shape. It is a curious fact that the impression of life (i.e. caterpillar movement) was once again mentioned only three times.

The result of the experiment is clear. Although in actual fact there was in both cases change in shape and forward movement, one of these becomes dominant under the influence of the speed factor, while the other is less marked and can even disappear completely from the phenomenal plane. At the same time there is an almost complete absence of any impression of auto-locomotion.

On the other hand, it is curious that not all the subjects who noticed both the displacement and the change in shape (at the fast speed) received the impression of auto-locomotion. The conclusion to be drawn is that even if the phenomenal existence of the two types of change is necessary for the creation of the impression of auto-locomotion, it is still only one of the conditions. This conclusion is confirmed by the following experiment, which is similar in principle to exp. 65 (the 'caterpillar' experiment) but in which a clear segregation of the forward movement and the change of shape has been obtained by giving them very different speeds.

in nature; thus swimming movements and the leap of a frog are very familiar cases. In both of them the head and the trunk are set in motion as a result of the bending of the legs, more particularly the hind-legs.[5]

The two cases of the 'caterpillar' and the 'frog' which we have just described represent characteristic types of animal locomotion; they undoubtedly provide sufficient material for a study of the questions of principle which arise with regard to the perception of this kind of movement. Moreover, in view of our claim that auto-locomotion resembles the phenomenon of propulsion, it was necessary to pursue our research with that point in mind, in order to find out to what extent and how exactly the two are connected.

A certain number of tests were made with this objective and with the 'caterpillar' experiment as our starting-point. Some of these will now be considered. The first shows that the two aspects of the operation, the dilatation-contraction aspect and the total movement aspect, must both *exist phenomenally* if the impression of auto-locomotion is to arise. This issue raises some difficulties, since the two 'aspects' are so closely linked that to distinguish them is a real problem.

The test in question consisted in the reduction of the caterpillar experiment to a single 'step' – i.e. to a single lengthening followed by a single shortening. This enables us to eliminate to a large extent either the impression of forward movement or the impression of change in shape of the object. (Which of the two is eliminated depends on the speed used.)

Exp. 68. A single object is present, consisting of a rectangle 16 mm. long which is in the middle of the slit in the screen.

The experiment consists of two phases; during the first, the rect-

[5] Exp. 67 shows several extremely odd features. Thus it is strange that, when the H end is being displaced towards the right at the same speed as the T end is being displaced towards the left during the first phase of the operation, the head appears motionless. It is no less strange that it is the movement of the tail *towards the rear* which seems to make the object move forward, and not its dilatation towards the front. This might seem to contradict our observations on the relationships existing between the direction of the movements and the causal impression (Chapter VI, 2, p. 101). We must not forget, however, that the 'motor' character of the tail-thrust, as was pointed out in the previous note, develops only if there is a bilateral dilatation, which in fact includes a dilatation of the object in the direction in which it is moving. Yet it remains none the less true that this displacement does not *seem* to have any effect. Here are very interesting problems of structure on which we unfortunately cannot linger now; an examination of them must be left for later research.

movement, the impression does not in the least correspond to the resultant of the two movements which is presented objectively. If it did, one would see simply an object whose head-part moved successively at a fast and slow speed, while its tail-part moved in the same direction first at a slow and then at a fast speed.

Now the actual impression is quite different, and the perceptual process leads to a complete analysis of the resultant into its geometrical component parts; in other words, one sees the object move forward continuously at the same time as it dilates and contracts bilaterally. The forward movement and the changes in shape appear as different movements, movements moreover which are absolutely independent of each other, and *there is no longer any question of auto-locomotion.* The complex physical stimulus situation thus brings about a dissociation on the phenomenal plane, where *two movements* are found corresponding to distinct systems of reference, internal in the case of the dilatation-contraction, external in the case of the forward movement. The contrast between the objective resultant and the movements perceived is striking, and it is particularly remarkable when one considers that the dilatation and the contraction of the object include movements apparently taking place in the opposite direction to that of the forward movement (i.e. T's movements during the dilatation and H's movements during the contraction), whereas the objective movements are made in the same direction.

This dissociation clearly represents the most simple and symmetrical structural organisation; for an organisation copied directly from the objective movements would involve not only great internal complication, but also a contradiction between the unity and simplicity of the object, and the diversity of the movements of its parts.[7] Moreover, as the two extremities of the object are all the time in motion in the same direction, conditions should be very favourable for creating the impression of continuous forward movement of the object as a whole.

A similar dissociation of movements (and the suppression of auto-locomotion) would of course be found where the speeds are equal, provided that segregation were ensured by a difference of direction (e.g. if the changes in size of the object were produced in a direction

[7] Similar contradictions occur in other cases also; in general, they are found to favour the establishment of structural organisations different from those which would simply be copies of the stimulus-conditions. Several examples are to be found in the research of A. C. Sampaio which I have already quoted (note 6, p. 39).

Exp. 69. A single object is present, consisting of a square of side 5 mm. which is placed at the extreme left-hand end of the slit. The experiment comprises a series of cycles, each divided into two phases.

During the first phase, the two ends H and T both move towards the right, H at a speed of 4·32 cm. per sec. and T at the slower speed of 2·88 cm. per sec. They thus gradually become farther apart, and this continues until the object has reached a length of 9 mm.

In the second phase, the two sides still move in the same direction, but the speeds are interchanged; they are respectively 2·88 cm. per sec. for H and 4·32 cm. per sec. for T. They thus draw closer together again, and this continues until the object has returned to its original dimensions.

At the end of the whole period, the square has moved 20 mm. towards the right.

In a variation of this experiment we used the two speeds 7·56 and 6·85 cm. per sec. during the first phase, and the same speeds the other way round during the second.[a]

To understand thoroughly the significance of this experiment it is important to realise that the movements of the extremities H and T comprise the geometric resultant of different movements, viz. (i) a continuous and uniform forward movement of the object, at a speed of 3·6 cm. per sec. in the first combination, and of 7·2 cm. per sec. in the second, and (ii) a *bilateral* dilatation of the object, alternating at intervals with a *bilateral* contraction, these dilatations and contractions being made on each side at a speed of 0·72 cm. per sec. in the first combination and at 0·36 cm. per sec. in the second.

The total speed of the lengthening or shortening of the object was thus 1·44 cm. per sec. in the first combination and 0·72 cm. per sec. in the second; and the speed of the forward movement was consequently either two and a quarter times or ten times that of the change in shape.

In these conditions, and especially in the case of the faster forward

[a] The disc designed for the first of these experiments was constructed as follows: it consisted of an arc of a circle 5 mm. thick, covering an angle of 40°. Then the inner side of the arc approached the centre with a slope of 0·06 cm. per degree, while at the same time the outer side approached with a slope of 0·04 cm. per degree, both for 20°; this corresponded to the first phase. The inner side then continued to approach the centre with a slope of 0·04 cm. per degree and the outer side with a slope of 0·06 cm. per degree, both for 20°; this was the second phase.

In the second combination, the respective slopes were 0·105 and 0·095 cm. per degree for the first phase, and 0·095 and 0·105 cm. per degree for the second; and the angular distance for each phase was 40°.

The rotation-time of the disc was 5 seconds in both cases; a greater speed seems less likely to produce a successful result.

tions and contractions, while in exp. 65 it was slower, the speeds being chosen expressly so that, in the resultant, each of the two ends of the object should advance in turn while the other remained still. The outcome is a considerable alteration in what we perceive, which now approximates more closely to the structure of the resultant, its analytical character thus being much less marked.

The impression is more in conformity with the resultant in that the object's changes in size are unilateral and successive, and are always made in the same direction, instead of being symmetrical and simultaneous. Again, the amplitude of these changes in shape corresponds to that found in the resultant and not to that of the corresponding changes in the component parts, which is only half the size.

On the other hand, however, the component parts are still represented, for there is not only dilatation and contraction but also forward movement of the object as a whole. Moreover, the phenomenal existence of this forward movement is clearly demonstrated by the remarkable fact that in this experiment the impression of locomotion usually develops only gradually. At first, all that is seen (as in exp. 68 – the single 'step' experiment – when performed slowly) is the changes in size; and it is only after a fairly long distance, consisting of a whole cycle or even more, that the character of forward movement asserts itself and auto-locomotion makes its appearance. The further question arises as to how to account for the onset of this impression of total forward movement, and how to explain why we do not see simply the two ends moving forward alternately, since this is what actually takes place in the resultant. The reason must certainly be sought in the similarity of speeds, amplitudes, and directions, in the temporal contiguity of the movements made by the two ends, and in the unity of the object; these are conditions which favour the integration of these part-movements in a total movement *which superimposes itself on them without fusing with them.* There is thus segregation of the movements and clearly also separation of their systems of reference; and in this respect the 'caterpillar' experiment comes close to exp. 69.

In spite of this, however, the part movements and the total movement are also very closely linked, since they have a number of identical kinematic properties; and in this respect there is a contrast between the two experiments, the auto-locomotion of exp. 65 being more like propulsion. Indeed these two phenomena differ structurally from each other in one respect only: in auto-locomotion we find unity of the object,

perpendicular to that of the forward movement, after the style of exp. 51, Chapter IX, p. 152). It is worth mentioning that this is to be seen at times in the case of animal movement – at certain stages in the flight of birds, for example, when we see their wings moving in a vertical plane while the forward movement is horizontal; the same sometimes happens in the case of swimming movements performed by fish, where the apparent direction of the movement of the fins does not coincide with that of the forward movement. In these cases there is no actual *impression* of auto-locomotion in our sense of the word.

The impression of auto-locomotion, then, certainly involves more than the simultaneous existence, on the phenomenal plane, of an object's forward movement and its dilatation and contraction, even when these are in a similar direction, e.g. horizontally, as in exp. 69. It is also necessary that these changes in the object should be *intrinsically* linked together. This leads us to make a new study of the caterpillar experiment and to compare it with exp. 69.

The objective conditions of these two experiments are absolutely alike *in principle*, as has already been pointed out. The curve on the disc used for exp. 65 also comprises the geometrical resultant of a continuous uniform forward movement and *bilateral* dilatations and contractions of the object.[8] The combination of the movements differs from that of exp. 69 only in one respect; the ratios of the speeds (the speed of the forward movement on the one hand and that of the dilatation and contraction on the other) are different in the two cases. In exp. 69 the forward movement was much more rapid than the dilata-

[8] In the case of exp. 65 (p. 184), the theoretical distance for the width of the dilatations and contractions is 16 mm. *on each side* of the object, so that the total size of the object alters by 32 mm. in the course of each phase. The theoretical distance for the forward movement is 16 mm. per phase; its speed is thus equal to *half* that of the change of shape.

The resultant of these two movements is established in the following way: during the first phase, the H end must advance 16 mm. as a result of the dilatation of the object and 16 mm. due to the forward movement; it is thus displaced for a total distance of 32 mm. In addition, the dilatation ought to have the effect of making the T end move back, but as this moving back has to take place at the same speed as the advance due to the forward movement, the two movements cancel out and T remains still. The object's centre of gravity, however, will clearly have moved 16 mm.

During the second phase, it is the forward movement of H which is neutralised by the contraction, while in the case of T the contraction adds its effect to that of the forward movement; T thus moves 32 mm. The centre of gravity in this case again moves 16 mm., so that it advances a total distance of 32 mm. during the whole period.

In spite of this, a sort of 'continuous ampliation', uniting the two 'movements', can be detected in auto-locomotion, and certain features of it recall causality, or at least are suggestive of it. In actual fact it is very difficult to describe exactly what is the distinctive character of auto-locomotion. Perhaps we might try to do so by saying, for instance, 'We see the object *advance* by virtue of the movements which it performs' or 'The movements of the parts can be seen *making* the object *go forward*'. We should distrust these expressions, however; set phrases are often misleading, and we must beware of giving these words the same meaning as in the case of propulsion, where we are also inclined to say that we can 'see the straightening of the bowstring *make* the arrow *go forward*'. The impressions are in fact very different, and it is obvious that we do not see the movements of the parts actually *produce* the object's own movement. In the overall impression the connexion between the movements is not sufficiently distinct for it to be directly evident how the movements of the parts result in the forward movement of the whole; only a systematic analysis allows us to gain a full 'understanding' of how this happens.

On the other hand, it is not a matter of simple identification in the sense that the movements of the parts *ipso facto* constitute the forward movement, nor even in the sense that auto-locomotion is only a kind of forward movement, a forward movement of a special qualitative type. There is certainly more to it than that; a general character of vague 'productivity' permeates the operation as a whole, and this colours the forward movement and gives it its special 'hall-mark'.

An amusing experiment, which can be carried out with no difficulty, shows in a particularly striking way (i) that the impression of auto-locomotion is connected with the fact that the two ends H and T belong to one and the same object, and (ii) that this impression does not result merely from the kind of movements that they perform. The experiment is identical with that of the 'caterpillar' experiment, except that during the movements corresponding to dilatation and contraction the head and the tail are separated from each other. All the properties of the movements, the distances between H and T, etc., are otherwise exactly the same as in exp. 65.

Exp. 70. The 'head' and 'tail' are represented by squares of side 5 mm., which are put side by side at the beginning of the experiment, so that at this point, as in exp. 65, we can see a single object consisting of a rectangle 10 mm. long, which is at the left-hand end of the screen.

whereas in propulsion there is duality. (The difference between the abruptness of the one movement and the continuity of the other is of only secondary importance.) It is therefore reasonable to apply to auto-locomotion certain conclusions obtained from the study of propulsion.

According to these conclusions, the change in shape has to take precedence over the forward movement, and there has to be in the propulsion a continuous ampliation to supply the basis of a permanent causal impression. Now in the case of auto-locomotion we seem to be able to find a similar priority – one that is accentuated by the fact that, as was pointed out just now, the impression of change in shape often appears earlier than that of forward movement. The latter therefore clearly develops *from* the former, so that that which was at first only change of shape *becomes in addition* forward movement of the object. The concept of ampliation and indeed of continuous ampliation can thus also be applied to auto-locomotion.

At the same time it should be remembered that there is no real causal impression in the present case; and this is so obvious that it took us a long time to realise what was the basis of the relationship linking auto-locomotion and the impression of causality, despite the fact that we had a feeling, even at the time of the first 'caterpillar' experiments, that such a relationship existed. In actual fact it was only after the question of propulsion had been elucidated that things definitely became clear. Thus the resemblance which we have established in the preceding pages must be considered to be another example of genetic analysis. What enabled us to establish the connexion between them was the comparative study of the simple and obvious case of propulsion together with the relatively obscure one of auto-locomotion.

It can be seen, too, that the unity of the object has a profound effect on what is given phenomenally, for even though an ampliation occurs in auto-locomotion just as it does in normal causality, the duplication takes place in very different conditions. The double representation in in the case of causality is bound up with the fact that the movement performed by the passive object belongs to the active object (see Chapter VIII). Here, however, only one object is involved, whose movements appear at one and the same time both as change in shape and as forward movement. The result is that we are no longer concerned with two distinct events – which is an essential feature of causality – but with a single event which is, indeed, a very complex one.

We might mention, for instance, the changes in shape of an amoeba, the beating of the heart in a physiological preparation, and other such examples. This impression sometimes occurs even in simple cases such as the straightening of a curve (as in exp. 46, p. 130), or the dilatation or contraction of an object. There are also plenty of examples of movements occurring in the world of inanimate nature which give analogous impressions, e.g. certain changes in cloud formations, the changes in shape of trees shaken by the wind, and the movement of the waves. (The latter frequently appear as cases of auto-locomotion in the full sense.) It is unquestionably the special character of these movements which give rise to the animistic tendencies so often reported in the interpretations put on these phenomena by primitive peoples and children.

We have started some special research with the aim of studying the impression of life; but as was said at the beginning of this chapter, there can be no question of describing it here. What is necessary, in my opinion, is to indicate briefly the conclusion to which this research seems to point, at any rate as it appears at the moment.

It is a very odd phenomenon that we see in the 'caterpillar' experiment. The lengthening and shortening of the object are coupled with changes which seem to take place throughout its whole 'mass', although this consists of a surface of an objectively uniform hue. The impression is like that which is to be seen when a balloon is inflated, or when we look at a motionless object after fixating for some time a rotating disc on which a spiral has been drawn.

The general appearance is as though the object were made up of an infinite number of particles, all simultaneously in motion. This movement is centrifugal in the case of dilatation, centripetal in the case of contraction, so that the final result is a state of complete *internal flux*. This reminds us in a strange way of what we see when we watch a caterpillar, a worm, or indeed any living animal. There is a similar movement in the microstructure of their surfaces as they change their shape; the name 'microkinesis' might perhaps be given to these movements of the microstructure, to contrast them with the macroscopic movements of the whole, or of its important parts. Now it might be supposed that the internal flux of our caterpillar is the result simply of an 'assimilation' with the data of experience common in everyday life. This is not in fact so, however; and it is easy to show that the appearance of this phenomenon in the case of uniform surfaces is essentially linked

The experiment consists of a series of cycles, each of which is divided into two phases.

During the first phase, the right half of the rectangle (object B) detaches itself from the left half and moves towards the right at a speed 2 to 6 cm. per sec. for a distance of 32 mm., while the left half remains still.

In the second phase, it is the left half (object A) which sets off at the same speed, and moves towards the right until it has rejoined the first half, that half having remained still.

The same cycle then begins again, and is repeated three or four times.

All impression of change in shape and of auto-locomotion has of course disappeared; and the procedure amounts to no more than a simple experiment of repeated launching. To describe the situation in our usual terminology, we can say that there is first of all an impression of withdrawal of object B from object A – a simple preliminary; then, in the second phase, object A sets off towards B and deals it a blow which sends it away. When B reaches the end of its journey, there is another movement of A, another impact, and so on.

It is very interesting to note that the hierarchy established here immediately after the first withdrawal of B is the opposite of that found in exp. 65. It is in fact object A (i.e. the T end of exp. 65) which has all the initiative and all the activity, while object B (i.e. the H end of exp. 65) is passive. Moreover the total movement of the objects towards the right does not appear as such. It is evident only to the extent that object A seems to 'pursue' object B and 'drives' it ahead each time that it rejoins it. Here it is clearly the relationships *between the two objects* that are dominant throughout the experiment. In the 'caterpillar' experiment, the gaps between these two objects are filled up. The unity of the object thus obtained brings about a completely new structural organisation. This change of organisation is reflected in the fact that the character of launching, which is essentially a *mechanical* one, is replaced by a character of live activity.

The contrast between the impression of life and that of mechanical activity raises a further problem, since it seems certain that the changes in shape of the 'caterpillar' possess in themselves all the characteristics of live activity, independently of the forward movement. This activity therefore appears prior, in principle at any rate, to the forward movement with which we have been concerned up till now; and indeed it is present also in a number of cases where the object does not move forward at all.

in auto-locomotion the forward movement is *extrinsic* to the object, since it consists of a change in position of the latter in relation to an external frame of reference. The impression of life might therefore be characterised as an actual visual impression of *immanent* mechanical activity; and this is very clearly shown by the fact that we find it necessary in our descriptions to use such expressions as 'It is something which moves of its own accord' or 'This object is the source of an activity which results in the object's own transformation'.[11]

It cannot be too much stressed, however, that such phrases are not really *descriptive* of the phenomenal data. They are too analytical to correspond adequately to the impression of immanence, which is much more a total impression whose character cannot really be described in words. Words belie the impression because they can only translate its elaboration by thought, and because unlike what happens e.g. in the description of the Launching Effect,[12] they introduce into it a separation which is not found in the perceptual data.

We do not *see* the internal flux *produce* the lengthening of the object in the same way as we *see* the impact *drive* the projectile forward in launching. (Nor do we *see* the lengthening *produce* the forward movement, see p. 194.) The same reason holds throughout: if there is to be a distinct impression of production, there must be a clear inter-connexion between events, and, where there is unity of the object, the phenomenal distinction between the movements does not dissociate them sufficiently to enable such a connexion to intervene.

On the other hand, there can be no doubt at all that there is a qualitative similarity between the impression of immanence (even in the absence of locomotion) and the impression of causality; and this similarity is of the same order as that which holds e.g. between a regular polygon and a circle. Once again we find this general character of 'productivity', whose existence we recognised in auto-locomotion; and this character is a positive 'invitation' to apply to these phenomena the concept of causality, on the understanding *that this concept has already been acquired from elsewhere*.[13] This application of the word, however, is

[11] The statement that the object is the 'source' of the activity fits well with the fact that the 'internal flux' is dominant and appears as the activity of the very substance of the object.

[12] See Chapter VIII, pp. 128-9 and 142.

[13] In the same way the resemblance to be found between regular polygons and the circle is an 'invitation' to apply to polygons the idea of a circle, i.e. to consider the latter as their 'limit', and to proceed from certain geometrical properties possessed by polygons to determine those of the circle.

with specific conditions of structural organisation, and in particular with the external shape of the object.[9]

It should be pointed out, however, that this 'internal flux' is phenomenally distinct from the change in shape itself, just as the external shape of the object is distinct from the mass or matter of which it is made. To such an extent is this true that it is perfectly possible for a lengthening to take place without there being any impression of dilatation; this is what happens, for example, when a line is drawn with a pencil.

The internal flux and the change in shape are nevertheless closely linked by their simultaneity, by their spatial relations, by the similarity of their kinematic properties, and by their belonging to the same object. Once more, then, we find a situation very like that of auto-locomotion, and we are again brought back to the idea of propulsion (propulsion Type II in the present case), and consequently to that of causality.

We might then be tempted on this account to assign to the 'internal flux' the rôle of cause in relation to the change in shape, granted that the latter is the result of the movement produced in the 'mass' of the object. This opinion could even find a semblance of confirmation in the fact that the impression of life seems to be linked with the establishment of an internal hierarchy which ensures the dominance of the 'internal flux' over the change in shape; in the absence of this dominance, the impression is quite different (e.g. like that given by elastic when it is stretched.)[10]

None the less, there is no question here of a causal impression in the full sense, any more than there is in auto-locomotion. Once again, there is only *a single event*, and it is always the unity of the object which acts against the separation, on the phenomenal plane, of a 'cause' event and an 'effect' event. Moreover the phenomenon derives its distinctive character from the fact that the changes in the object are both *intrinsic*. It is the *actual substance* of the 'caterpillar' which is in motion in the 'internal flux', and it is *the same substance* whose shape evolves, whereas

[9] See in this connexion A. C. SAMPAÏO, op. cit., p. 20. This point cannot be discussed further at the moment.

[10] The total forward movement which is produced in auto-locomotion seems to be very important in this connexion, whereas the conditions of expts. 68, 15 and 16, and 22 and 23, seem to be less conducive to this effect. An inverse hierarchy can also be established, as in the case of the elastic, and it is even possible sometimes for there to be simple co-ordination of the two movements, without any real dominance of one over the other.

CHAPTER XIII

Tactile-Kinaesthetic Perception of Mechanical Causality

At the beginning of the chapter on auto-locomotion it was pointed out that the most common cases in which there is visual perception of causality were those involving human activity. It is also clear that the activity of one's own body, and in particular the activity of one's own hands in manipulating external objects, provide abundant impressions of this kind. These activities, however, have also another more inward aspect to them – their tactile-kinaesthetic aspect. It is therefore appropriate to ask whether there are causal impressions in this sphere also, and whether they exemplify the same principles as those which hold in the case of vision.[1] The question is the more important because many writers, as we know, have claimed that 'muscular sensations' play a predominant part in originating our idea of causality.

It should be made clear, however, that up to now we have done virtually no systematic research along these lines. As a result I shall necessarily have to limit myself to the exposition of some points of a general kind, and to a tentative application of our earlier conclusions to this new sensory field.

made possible only by an artifice, viz. an abstraction which allows the phenomenal distinction of the 'movements' to be so much exaggerated that it is represented on the conceptual plane by the fiction of a duality of events.

All this, therefore, leads to the important conclusion that there is a basic impression, a specific phenomenal datum, of immanent activity in the field of the visual perception of movements, and that this phenomenon is clearly differentiated from the impression of pure causality. We have here a fact of enormous significance not only from the point of view of understanding the behaviour of animals towards each other (flight, pursuit, etc.), but also from a theoretical point of view, as will be seen later.

In the case of auto-locomotion, the structural organisation seems very complex. On the theoretical side it involves the coupling of two 'pseudo-propulsions'; immanent activity acts in conjunction with locomotion, and gives it its characteristic impress of life. This is why our immediate reaction is to say that we see the animal not only moving the parts of its body, but *travelling* or *going along under its own steam*. The situation is still more complicated, of course, when the forward movement of the animal plays the part of 'cause' in a launching or an entraining (see in this connexion expts. 71 and 72, pp. 210 and 211), or when we see the animal or the man acting mechanically upon an object through the intermediary of a tool, as in the examples quoted at the beginning of this chapter and the preceding one.

corresponding to the same or similar kinaesthetic stimulations when these are not acting in co-operation with the same group of exteroceptive data.[2] Thus we need only reproduce in the air the movements which we go through e.g. in feeling an orange to realise that the impressions are quite different. We are no longer concerned with the shape of the space between our fingers but with movements of the fingers or changes in the shape of the hand. In the same way, as we all know, the impression of an object's weight is quite a different thing from the sensations of stretching or squeezing felt in our limbs when we take up the artificial attitude which we call 'introspection'.

Impressions whose origin is proprioceptive belong from a phenomenal point of view to two systems which are differentiated both by their character of objectivity or subjectivity and by the *quality* of the perceptual content – weight or stretching, shape of object, movement of the fingers, etc.[3] Somatic impressions, in the strict sense, form a special class, and there is only one object whose boundaries they mark, viz. our own body.

We must next make a distinction between different situations in which one can think of the body as being involved. It can be isolated from external objects as regards sensory awareness,[4] or again it can stand in some relation to them; in particular, it can perform a mechanical action on them, or have a mechanical action performed by them on itself. (We must include in this group those situations where there are 'external' mechanical relations between different parts of the body, e.g. when one arm lifts another.)

As for the isolated body, it can be thought of either as being motionless (or as nearly motionless as possible) or in a state of movement.

From our present information on the subject, it seems that where the

[2] This can also be seen in cases when the movements of our limbs give rise to impressions of movement of external objects, as in the examples quoted on p. 202 and following. In addition to the difference between them as regards subjectivity or objectivity, these movements differ qualitatively in that a character of immanence attends them in so far as they belong to the body (with rare exceptions), while this is lacking in so far as they appear to belong to external objects.

[3] A remarkable example of this dimorphism and the quantitative differences in sensibility which accompany it has recently been studied by Katz. See D. KATZ, Gestaltgesetze des Körper-Erlebnisses, *Acta paediatrica*, XXX, p. 359, 1943.

[4] This 'isolation' can, of course, occur only if the sensitiveness of the skin to heat becomes completely adapted to the temperature of the external environment and if the pressure exerted by the environment on the organism is uniform.

Effect. Similarly, when I push away or lift something, or when I am in a vehicle which begins to move, there is an impression of entraining. When I squeeze a ball and it changes shape, or when I make use of most tools, I receive a typical impression of propulsion. There is also an impression of propulsion when someone else wrinkles up my skin by pinching me, or bends my arm, and also in certain physiological activities such as mastication, deglutition, defaecation, etc.

Before examining our problem in detail, we must remind ourselves very briefly of some essential points about our own bodies viewed *kinaesthetically*. From this point of view the body is a very strange and indeed unique thing in our experience. Even the use of the word 'thing' to describe it requires some qualification, for it is clearly not a 'thing' just like other things; it is comparable with the things which we see and touch only to a limited extent. In particular, it has the distinctive character of being one's bodily 'self' and of appearing as *one's own* body. Moreover, whereas we come across a multiplicity of 'things' in the visual or tactile fields, one's body is the only one of its kind from a kinaesthetic point of view (except on those occasions when there is empathy between our own bodies and those of other people or animals perceived visually).

Unfortunately there is some confusion on this subject, since people generally attribute to the 'sense' (so-called) of kinaesthesis not only the impressions of movement in our limbs and our postural awareness (stataesthesia), but also our impressions of the resistance, hardness, weight, and shape of external objects. This approach derives from the traditional theory of sense-perception and the custom of classifying 'sensations' according to the different receptor organs by which they are mediated. In fact, however, the stimulation of the organs of deep sensibility gives impressions of two very different types, according to the conditions of the total situation in which they occur, which determine whether they are 'objective' or 'subjective'. When deep stimulation in the joints and in the muscles and tendons occurs at the same time as cutaneous stimulation, and operates in conjunction with it, our impressions have the character of being impressions of *external* objects, and appear with a well-defined *qualitative* character as properties of these objects. This holds, for instance, in the case of impressions of weight or shape. Weight and shape are unquestionably inherent in the 'things' themselves and constitute altogether different data from those

dimensions and even a fairly definite total shape, but seems to float in a more extensive space, without its boundaries being at all clearly marked.

There is another difference between the body and the visual amoeba. The latter is made of a 'matter' (coloured surface) which has a microstructure and a fairly clear internal differentiation (vacuoles, etc.). The sensory 'matter' of the body, on the other hand, i.e. the modality of somatic impressions, is fairly uniform, and it is difficult to say anything definite about its nature. Writers in general speak of it as having a vague relationship with tactile-cutaneous impressions of touch and pressure; but they are unanimous in saying (to use the traditional terminology) that 'sensations' are not experienced in the ordinary way in the case of the body. Moreover it is a feature of these impressions that we use to describe them words of *purely formal* meaning such as 'kinaesthesis' and 'awareness of bodily states'. Another difference is that the kinaesthetic 'matter' of the body does not seem very compact; its apparent 'density' is certainly much less than that of the solid objects which we see or handle; and if we want to make a comparison with visual impressions we should have to regard the 'matter' as similar to volume colours or 'Raumfarben'. As for the impressions said to be 'coenaesthetic', they do not really help at all in making clear the constitution of the body; these overall impressions such as the feeling of well-being, bodily freshness, discomfort, and so on, appear to be 'states' of the organism, and are agreed to belong rather to the class of data of an affective kind.

The upshot of all this is that the special peculiarities of the kinaesthetic body – its 'fluidity', the lack of internal differentiation and organisation, the absence of precise boundaries, and so on – are in contrast with the most striking properties of phenomenal 'things'; and we are therefore very hesitant to say that the kinaesthetic body is an 'object' or a 'thing' at all. This makes it easier to understand a conclusion which we shall reach later in discussing voluntary action. In spite of this, the character of 'being an object', indeed a permanent object, can clearly belong to our body as perceived kinaesthetically; and this occurs as a result of the influence of the same factors which in general give rise to phenomenal permanence in objects, i.e. constancy of qualitative appearance of the sensory 'matter' or 'stuff' of the object (however little this aspect may be noticeable) and continuity in the changes of the object's shape.

Again, the body takes on a very wide range of different forms. Not

body is motionless the outcome is the opposite of what happens in other sensory fields; there is an almost complete adaptation of the receptor organs, and the result is that the body simply disappears from the phenomenal world. This is indeed what seems to happen to a very high degree in the practice of certain oriental sects, where those who are expert are able, by remaining motionless, to achieve an extreme state of apparent 'spiritualisation'. Movement appears to be essential to the phenomenal existence of the body, and it is probable that we are aware of our bodily states only in so far as they are terminal phases of movements. In our ordinary waking life, of course, our bodies are motionless only to a relative extent; there is nearly always movement, if only as a result of respiration.

Whether it is temporarily motionless or whether it is moving, the body appears as a somewhat shapeless *mass* or *volume*. There is very little by way of internal organisation or connexion between the parts. There is no clear marking off of the head, trunk, and limbs by precise lines of demarcation. The link between them is rather like that between the 'head' and the 'tail' of our 'caterpillar' in exp. 65. Instead of any precise line of demarcation we find a number of regions with extensive connexions between them gradually merging into one another.

We can with some justification look on the body as a sort of *kinaesthetic amoeba*, a perpetually changing mass with loose connexions between the parts, and with the limbs constituting the pseudopodia. There are, however, very marked differences between this kinaesthetic amoeba and the amoeba seen under the microscope. The latter has a contour separating it from its background, while this feature is clearly lacking in the case of the body in isolation. The 'volume' of which it consists is not limited by a clearly defined surface, and there is no 'contour'. This is a point of considerable interest, and it necessarily follows as a result that the *whole* of the kinaesthetic field of bodily sensations is filled by the body. In these conditions there can be no question of any distinction between figure and ground such as occurs in the visual field, where the ground provides impressions of the same modality as that of the figure. The limit of the body is more like the limit of the visual field – an imprecise frontier which has no line of demarcation, and indeed which cannot without absurdity be imagined to have one. Again, just as the limit of the visual field does not mark the end of phenomenal space,[5] so it is with the body; its 'volume' appears to us to have certain overall

[5] On this point see, for example, W. METZGER, *Psychologie*, pp. 31 seq.

already been pointed out, perfectly clear causal impressions can be obtained.

These sometimes occur in conditions which are almost identical with those which we meet in the inanimate world, e.g. in the performance of so-called 'passive' movements, when the body or limbs deal or receive a blow with the muscles completely relaxed.[6]

Here is an example. Let us suppose that the subject's arm is completely relaxed, and is being held in a horizontal position at shoulder height by an assistant who at a given moment lets it go and allows it to fall as a result of its own weight. Let us suppose that the arm during its descent strikes some movable object, e.g. a ball. Now it is *possible* that the subject may have the impression that his arm launches or entrains the ball. In this case the arm is acting like any other moving object, and the situation is similar to that shown in Fig. 7, F, p. 170. The arm performs a rotary movement round the point where it is attached and produces a forward movement of the object struck; and since the movement of the arm occurs earlier in time than that of the ball, it appears to be the cause of the ball's movement. None the less, this experiment is different in several respects from a comparable visual experiment with inanimate objects, and this fact needs to be stressed.

In the first place the experiment is not always successful. Sometimes there is simply the impression of two successive events more or less independent of each other, the two movements in that case being separate. If they are to form a unity, the movement of the arm must have as little reference as possible to the rest of the body. The more the phenomenal unity of the organism is accentuated, the less chance there is that the movement of the arm will be integrated with that of the ball in a causal event. There is the same difficulty here that we have already met on several occasions, and it is one to which we shall return in a moment.

Secondly the experience in this case seems very different from visual experiences in that vision enables us to perceive the whole length of the paths followed by the objects, whereas in this case we do not begin to perceive the object until it comes into contact with the surface of the skin, and we stop perceiving it as soon as it is even a very small distance away. Thus the phenomenal movement of the object is confined to the

[6] I am ignoring for the moment the more complex cases in which the 'passivity' is of the sort found in *forced* movements, i.e., movements which are imposed from outside despite active resistance.

only does its shape change, but its whole structure varies appreciably according to the circumstances. Thus when we are lying still in bed we soon find different parts of the body becoming dominant at certain times and the total organisation becoming altered when a pain or tickle of internal origin is located in the part in question. These parts can sometimes actually seem separated from the rest by 'gaps', the result being a sort of dislocation of the whole.

In the ordinary way, however, the lack of any clear demarcation between the parts gives the kinaesthetic body a very marked unity. In our kinaesthetic amoeba, just as in the visual amoeba, there can be changes in shape; and in both cases alike conditions occur in the course of these changes which are highly favourable to the impression of immanent activity discussed at the end of the last chapter. Moreover these *changes in shape* most often appear as *movements* even when the organism is isolated. There is often a relative segregation between different parts of the body (arising from the fact that one part is in motion, another not), sufficient for the second to take on the rôle of 'external' centre of reference for the first; there thus occur *changes of distance* between the parts and also phenomenal movement. It is possible, for instance, to feel our arms *approach* or *move away from* our trunk; and this constitutes a genuine case of auto-locomotion, or rather of 'auto-motion', since there is no question of a change in position of the whole. All that was said above on the relationships between the 'internal flux' and macroscopic movements (p. 197) clearly applies here. In particular we can draw the inference that the movements of the isolated body must show the overall character of 'productivity' mentioned above, and that the body must appear as being the *source* of the movements which it performs.

These movements, however, are not at all of a kind to result in impressions of mechanical causality in the full sense. The overall unity acts the opposite way, just as it does in the visual field. Thus when adjoining parts of the organism change their position successively, the movement of one of them in no way seems to be the cause of the movement of the other. Movement of the upper arm, for instance, does not seem to be the cause of the subsequent movement of the forearm. They are both the act of one and the same 'object' and simply make up the different stages of an operation of the whole in which they are integrated.

When we come to consider the relations between the body in motion and external objects, the matter is quite different. In this case, as has

sure (or the pull) has overcome the inertia of the limb, the limb in its turn will begin to move, and we may assume, for the sake of simplicity, that the indentation of the skin then remains constant. In spite of this the stick will continue to give the impression that it is moving; the kinaesthetic data from the joints and from the muscles and tendons ensure the persistency and continuity of this movement, although at the beginning only cutaneous kinaesthetic stimulation was involved. What is very curious is that we perceive the movement of the arm and the movement of the stick *at the same time*; the stick seems to communicate *its own* movement to the arm, whereas the sensory stimulations come from the displacement of the arm itself. We have here a real paradox, one which results from the priority of the movement of the stick, and which serves to emphasise the full importance of the hierarchy of priority. In addition we have here a very good example of phenomenal duplication, theoretically similar to those which we discovered to occur in all cases of launching and entraining, but particularly striking in this case. Incidentally it is obvious that we need only reverse the situation and begin the operation with the movement of the arm, and the direction of the causality is also reversed; the movement of the arm will then become the 'motor' movement. Thus our next step in the study of the perception of causality is to examine 'active' movements.

A very simple example is afforded by the use of reflex reactions. We can produce the required conditions by touching off a reflex, e.g. the patellar, after placing some object in front of the observer's foot or leg in such a position that it will be entrained or launched when struck by the limb. In these conditions it is at least *possible* to obtain causal impressions, just as it was in the experiment in which the passive limb was allowed to fall. In both cases, however, and for the same reasons, causal impressions are certainly not obtained regularly. It frequently happens that the two movements appear separate and there is no actual *impression* of causality (even though, of course, subjects may say after reflection that there was a causal link between the two events). In the present case, too, there are more cogent reasons for failure than in the case of passive movements; the reflex does in fact give a clear impression of immanent activity or auto-motion. When people try to describe this impression, they say it feels 'as if the limb were lifting itself up of its own accord'. The limb does not just 'start off' in the way in which an inanimate object starts off. Nor does the movement appear to be brought

very small distance over which it dents the skin. Now it is known that indentations produced by gradual pressure, like the sliding of the surface skin over the tissue that lies below, sometimes give impressions of movement (of a kinaesthetic cutaneous type),[7] the effect of which is to produce changes of distance between the body and the object. The indentation of the skin corresponds to an approach, while the regaining by the skin of its original form through its elasticity corresponds to a withdrawal. Moreover this change in distance, considered on its own, is ambiguous in much the same way as it is in some conditions in the visual field;[8] it is the forces of organisation that determine which of the two objects seems to move in relation to the other. In the example just quoted, the indentation of the skin is a continuation of the earlier movement of the arm; it is the arm therefore which appears to do the approaching, while the recovery of the surface after the arm has stopped moving forms a withdrawal movement on the part of the ball.

The situation is thus similar in principle to that in our visual experiments, and differs only quantitatively, viz. in the extent of the movements. We should remember, however, in this connexion what was said earlier[9] about the relative unimportance of this distance in giving rise to the causal impression. Another point to be remembered is that indentations of the skin which occur when an object strikes us may be very large compared with the minimum indentation which can be felt. This is sometimes as little as a micromillimetre;[10] an indentation of a millimetre is thus a thousand times larger!

Here is a second example of a causal impression in which passive movements are involved. If I am holding a stick in my hand, and my arm hangs loose, with the muscles relaxed, and an assistant moves the stick horizontally, as observer I shall have the impression that my arm is entrained by the stick. It is the stick this time which is the motor object, and the arm simply participates in its movement. The situation here is the same as in all the cases of entraining described so far.

The operation begins with a sliding movement of the skin produced by the push or pull exerted on it by the stick. In the total conditions in which the experiment is performed, this gives rise to the impression of a movement of the object, i.e. the stick. From the moment when the pres-

[7] See H. PIÉRON, Le Toucher, in *Traité de physiologie normale et pathologique*, ed. Roger and Binet, Vol. X, p. 1108, Masson, Paris, 1935.
[8] See K. DUNCKER, Über induzierte Bewegung, passim.
[9] See p. 57.
[10] See H. PIÉRON, op. cit., p. 1087.

of the caterpillar's movement is thus made less noticeable, there is more chance that the observers will see a Launching Effect; on the other hand, if their eyes follow the caterpillar, the Launching Effect disappears. Moreover the Launching Effect can be made to reappear immediately in a clear form if we fit a shutter to the slit in the screen in such a way as to hide the caterpillar until it is only 2 cm. from object B. In these conditions, we see object A emerge from behind the shutter, slide towards object B, and then strike and launch it. As one might expect, however, there is no longer any trace of a change in shape or of auto-locomotion on the part of object A; it acts like a billiard cue coming up and striking a ball. Thus when auto-locomotion is abolished, the Launching Effect reappears.

On the basis of our existing data it seems likely that the principal obstacle to the production of the causal impression in this experiment lies in the difficulty which we have in integrating in one whole the auto-locomotion and the forward movement of the second object. There was the same difficulty in the case of the reflex movement. Positive results should therefore be obtainable if conditions are created which favour the formation of an overall unity. There is a fairly simple way of doing this. What is required is to replace the launching conditions by entraining conditions (or by launching conditions which follow a momentary entraining). The fact that the movements are identical and simultaneous establishes a closer link between them than that which occurs in the case of launching-by-striking. Here is an experiment carried out on these lines.

Exp. 72. This experiment is similar to the previous one, except that this time object B is placed 80 mm. to the right of the 'caterpillar' when it is at rest, so that the latter reaches it in the middle of its third 'step'. As soon as contact is made, object B in its turn begins to move, at the same speed as the 'head' of the caterpillar, and is thus moving beside it for the rest of the distance covered in the third 'step' – i.e., for 16 mm. At this moment the 'head' comes to a halt, but object B continues to move at the same speed. The speed of the movements of the 'head', the 'tail', and object B was 6 cm. per sec.

As was expected, the Entraining Effect and even the Launching Effect are clearly to be seen in these conditions. We may therefore conclude that powerful unifying factors must be operative (linking the 'caterpillar' with object B) if the causal impression is to be received in the case of such movements of auto-locomotion, since they tend by nature to be withdrawn, as it were, into themselves.

about by the striking of the patellar tendon, for there are several factors which operate against the occurrence of a causal impression in these conditions. These include the difference between the direction of the striking movement and that of the movement performed by the limb, the distance between the point struck and the place where the impression of the leg's movement is localised, and probably also the time-lag between the impression of striking and the impression of movement. Moreover the impression of auto-motion is favoured by the fact that, when movements are brought about by muscular contraction, the limb begins to move only when the contraction and tension of the tendon are sufficiently pronounced. Impressions corresponding to the changes in the surface of the skin must therefore have priority over the impressions which result from the movement itself, and the dominance of 'change in shape' over 'forward movement' must be accentuated.

Now as we have already noted on several occasions, the existence of an internal system of reference, which is particularly marked in auto-motion, is necessarily an obstacle to the production of causal impressions. This can easily be shown, in the visual sphere, by means of an alteration in the 'caterpillar' experiment as a result of which the character of auto-motion is similar to that of the reflex movement of the leg.

Exp. 71. This is the same as exp. 65 with the addition of a motionless object (object B of the ordinary experiments) placed 96 mm. to the right of the 'caterpillar' when it is at rest. The 'caterpillar' moves its 'head' forward at a speed somewhere between 3 and 9 cm. per sec., until its total length has increased from 10 to 42 mm. The 'head' then remains still, and the 'tail' begins to move in its turn at the same speed until the total length is reduced to 10 mm. The 'caterpillar' in this way makes three 'steps' towards object B, and reaches it at the end of the third step. At this moment object B begins to move in the same direction at a speed somewhere between 2 and 6 cm. per sec. During this time the 'head' remains still and the 'tail' is brought up into position.

It is clear that the situation produced at the moment when one object encounters the other is similar to that of the ordinary launching experiment. The only difference is that object A has performed a movement of auto-locomotion before reaching B. Now the Launching Effect is practically never found in this case. The observers who took part in the experiment were in full agreement; what they saw was at most a triggering. Once again, however, the result depends to a great extent on the fixation. If object B is fixated throughout and the distinctive character

fall of a limb). The conditions are such that our own activity and the change produced in the object must constitute phases of a single total operation.[12]

There is, however, a further difference between cases of reflex and cases of voluntary action which is much more fundamental and also much more odd. In the case of the patellar reflex, for example, we receive the impression that the leg moves of its own accord and may push an object lying in front of it. Thus the auto-motion and the causality appear to belong to the leg-object or, to be more exact, the object 'my leg', a part of the body which at this moment has become more or less autonomous. In voluntary action, on the other hand, it is no longer the moving limb which seems to *move of its own accord* or cause an external object to move; it is *I myself*! *I* start it moving, *I* push my leg forward, *I* launch a particular object by kicking it, and so on. The limb is now only an instrument of 'me'; the situation is similar to that which occurs when we use an implement, e.g. when we push a pebble with a walking-stick, yet say 'I am pushing this pebble'.

The difference between voluntary action and reflex action is seen very clearly from the fact that it is always the same 'I' taking part, whatever limb is being used, and that this 'I' is always wholly involved in each action, however small it is, and even if it comprises no more than e.g. bending the end of one finger, while the rest of the body does not move.

We thus come to the conclusion that in voluntary action the 'I' is *substituted* for the body (or the limb) as the object performing the movement and as the 'source' of the movement. It apparently plays *the same part in the total structural organisation as does the body-object* when we perceive auto-motion and causality.

This substitution of the mysterious and elusive 'I' for the limb which actually does the striking is something which presents a curious problem of its own. This problem becomes still more puzzling when we remember that the word 'I' is not being used as a synonym for 'my body' (although this sometimes occurs in ordinary conversation), and does not refer to an *object given in perception* at all, even an object of a rather peculiar kind. As has often been pointed out, the basic 'I' or 'self' would then cease to be itself; its internality is essential to it, and this internality is clearly incompatible with the phenomenal character of 'object' or 'thing' which can be observed or considered.

[12] See the reference made to pseudo-intentionality in connexion with exp. 16, p. 67, which was of course a visual experiment.

Finally, a few words should be said on the subject of voluntary action. In particular, there is a special problem arising from the truth of the two following propositions: (*a*) When our bodies respond to a stimulus, and when, as sometimes happens, an impression of causal activity is produced, this causal activity is not necessarily the product of voluntary action, since purely passive movements, such as the fall of a limb or the whole body, and reflex movements can give rise to causal impressions in the full sense. (*b*) Impressions of auto-locomotion (and of immanent activity in general) are not limited to those occasions when action is voluntary; on the contrary, they can occur when there is reflex action, and they can occur in the case of external objects perceived visually.

Granted that this is so, the question arises as to what are the differences between causal impressions (or impressions of immanent activity) which occur in connexion with reflex movements and those which occur when there is voluntary action on external objects. I shall therefore consider voluntary action only from this very limited point of view, and shall deliberately leave out all questions connected with the 'will' in the strict sense, and with decision, motivation, and so on.[11]

In this connexion it is particularly striking how constant and universal is the causal character which attends voluntary activity performed on external objects, whereas this character is often lacking, as we have just seen, when objects change their position as a result of reflex movement. When we push, launch, or lift an object voluntarily, what is involved is not a simple triggering off of a movement owned by the object in question; it is *we ourselves* who are making it move. This difference seems to be of the same kind as that found between the result of exp. 71 and that of exp. 72; in the present case, too, the important factor is probably that of integration. Indeed the *intentionality* of the voluntary action necessarily implies a subjective attitude closely linking the movement of the object with our own activity. This link is the stronger because, as we know, what is *aimed at* is the movement of the object itself, not the movement which we have performed in order to change its position. We act in order to achieve this or that result, or at least we have the impression of acting in order to achieve it; consequently the encounter of our limbs with the object cannot appear merely as a chance event (as in the cases of reflex action or the passive

[11] Since the purpose of this book is to study the perception of causality, it need scarcely be added that we shall not be concerned with problems of 'internal' voluntary activity.

intervention acquires a completely new *meaning*, a new significance, which affects our behaviour. It is still true, however, that the character of immanence possessed by the movements of the body and the causal character attending the movement of the passive object still satisfy in principle the type of structural organisation which we have labelled 'ampliation of the movement', and appear in conditions which give rise to it.

This way of looking at the question has the advantage that it presents the basic problem in rather more precise terms. What we have done is to emphasise how, from a structural point of view, the 'I' takes over the rôle of the 'body-object', and how the body is allowed to survive only in the form of a 'pure' motor activity – an activity characterised by the fact that it is 'mine'.

No one, I am sure, will expect in this book a solution to all the many difficult problems to which this approach gives rise. One of the most intricate of these problems is whether the character of 'mine-ness' necessarily belongs to an immanent activity as soon as there is no longer any phenomenal object to display such activity. To examine these questions seriously would involve a detailed discussion of the distinction between object and process, of the conditions in which this distinction can be seen, of phenomenal activity, of the relations between the impression of 'selfhood' and the concept of 'self', etc. All this lies outside the scope of our present enquiry. As far as this book is concerned, it has been enough for us to show that the intervention of the 'will' does not introduce anything new which is of cardinal importance for the *impression of causality* as such; indeed, on the contrary, the appearance of this impression was found to be connected with the same conditions of organisation in cases of voluntary action as it was in cases of involuntary action and even in cases of visual perception. In addition these conclusions are perhaps ones which may throw light on a problem which we shall touch upon later – that of the rôle of voluntary action in originating the idea of causality.

It seems, therefore, that when we engage in voluntary action we do not have the impression of an 'I' *which* moves, *which* launches, or *which* pushes, but rather the impression *of moving* (in some way determined by the somatic kinaesthetic data), *of launching*, or *of pushing*. It is an impression of auto-motor or causal activity which is personally experienced, which is '*mine*', but nevertheless does not *result from something which is the self*. In this respect, our voluntary activity is clearly different from similar activities of which we are the observers, as happens in the case of the visual experiments described earlier, and even in the case of reflex action.

In short, it seems that voluntary action on external objects has the appearance phenomenally of an *immanent* activity (whether simply auto-motor or causal as well); this activity is 'pure' in that it does not 'belong' to any perceived object, but has a special qualitative character of 'selfhood' as a result of which it appears as 'mine'.[13]

We saw earlier how proprioceptive impressions could be divided into two kinds, according to whether the movement belonged to external objects or to the body itself. Here we are classifying them in another way, according to whether the movement performed by the 'body-object' is its own or is 'detached' from it.[14] Again, the properties of the 'body-object', viewed kinaesthetically, are such as favour particularly the possibility of its becoming blotted out from the phenomenal field. We have already had occasion to comment on the great differences between the qualities possessed by the 'body-object' viewed kinaesthetically and those ordinarily found in the 'things' which we perceive visually.

We may conclude from what has just been said that, in the case of voluntary action on external objects, causal activity loses not only its purely mechanical character (in that it becomes an example of immanent activity, like reflex action), but also to a large extent its character of being performed by the body. As against this, however, it becomes integrated in the much more comprehensive unity provided by decision and motivation. All this is important because as a result the causal

[13] This impression of 'pure' auto-motion is presumably the phenomenal datum from which is derived the so-called 'feeling of innervation', which we have already discussed at some length.

[14] It would be interesting in this connexion to look for a theoretical link between voluntary intervention and the pure phi phenomenon (mentioned on p. 137), and to try to make precise what in that case would be the most favourable conditions for producing the latter.

CHAPTER XIV

Ampliation of the Movement

During the course of this book we have studied many varieties of causal impression, which we can now classify into two main groups. The first group comprises launching in its various forms and triggering (which is a weakened form of launching), while the second comprises entraining, propulsion and auto-locomotion.[1]

It is characteristic of all cases of launching that the causal impression involves the *separating* of the passive object from the active one with which it was previously united. This separating lasts either for a very short instant, as in launching-by-striking, or over a longer period, as in launching-by-expulsion.

It is characteristic of entraining and its derivatives that the causal impression in this case involves the *union* of the passive object with the active one, which afterwards shares with it kinematically the same 'common fate'.

In spite of the apparent dissimilarity between these two groups of phenomena, they can both be brought together under one and the same basic concept, that of ampliation of the movement. This can be defined in a very general way as follows: ampliation of the movement is a *process which consists in the dominant movement, that of the active object, appearing to extend itself on to the passive object, while remaining distinct from the change in position which the latter undergoes in its own right.* (We may assume that the 'movement' of the active object and the 'change in position' of the passive object can sometimes be seen as part of an overall 'change in shape', and that the active object and the passive object can sometimes be one and the same object.)

This definition is necessarily very abstract, since it has to apply to all cases of perception of causality; but in spite of this it serves to establish a number of important conclusions.

[1] The impression of live movement is, of course, different from that of causality in the strict sense; but since we are concerned here to discuss the theory of ampliation, and ampliation plays a part in auto-locomotion, the phenomena of auto-locomotion (as well as those of causality) are taken into account in what follows.

General Conclusions

of impressions of attraction, repulsion, or active resistance (when a moving object approaches a motionless object, withdraws from it, or stops at the moment when it reaches it).[3] The same holds also of cases where an object strikes or hammers another and the latter undergoes no apparent change.

In addition, the change in the passive object must remain distinct from the movement of the active one. Thus there can be no question of any perception of causality where a single object performs successive movements of the same kind. These movements are found to merge completely and form a single movement whenever the interval between them is of the length required for the appearance of the causal impression. 'Live' movement is the only example which we have met where two 'movements' of a single object gave rise to ampliation; and this was made possible by the difference in kind between the movements – forward movement and change in shape.

It is obvious, however, that ampliation presupposes a certain degree of similarity between the movement of the active object and the change which takes place in the passive object; otherwise this change could not appear to be an 'extension' of the active object's movement. This is why there is no causal impression when the displacements of the two objects occur in diametrically opposite directions, or even when there is a considerable difference of direction. Thus it is impossible in principle to produce an impression of active attraction by making one object (object A) move towards another (object B) at the moment when B is approaching A.[4]

Another feature of ampliation is that it covers only the time during which the extension of the movement is being established. The result is that in the case of the pure Transport Effect, which involves a static structural organisation, no causal impression occurs.

Again, ampliation presupposes that the movements are hierarchised,

[3] It will be remembered that in these conditions we sometimes receive the impression that the object 'ought' to go farther; but this is quite a different matter from the impression of an active influence exerted by the motionless object.

First of all, we can deduce from it that the two main groups of causal impression which our observations have led us to distinguish are the only conceivable basic forms which ampliation of the movement can take.

The extension of the movement of the active object, which is the essence of ampliation, is dependent on the movement of the passive object being partially identified with the dominant movement, that of the active object. Now such an identification can take place in two ways only. Either the movements must be *successive* or they must be *simultaneous*. When they are *successive* – or, rather, when the displacement of the active object no longer plays any part in the causal impression after the impact – identification is possible only if the movement of the passive object appears to be the *continuation* or the *prolongation* of that of the active object.[2] This is what occurs in all cases of launching. When the movements are *simultaneous* – in other words when the displacement of the passive object and that of the active object continue together after the impact – identification is possible only if there is *fusion* of the movements because they are kinematically similar. This is what occurs in entraining, and also in propulsion and auto-locomotion. As we have seen, the last two are simply entrainings which are being continually renewed.

There are two sorts of extension – extension by prolongation and extension by fusion. *There are no other alternatives.* It follows that it is *impossible in principle* that there should be any types of causal impression other than launching and entraining. As far as this particular question is concerned, our enquiry is thus exhaustive.

Secondly, the concept of ampliation enables us to discover the basic reasons why the impression of causality cannot appear in the many *negative cases* mentioned and discussed during the book. These were cases which seemed *a priori* as though they ought to favour a causal link; but in all cases some important feature of ampliation is missing.

Thus, since ampliation presupposes by definition that there is both a movement of the active object and a modification in the passive one, it is clear that there cannot be any causal impression in cases where one of the two objects is static. This excludes from the outset any possibility

[2] The wording used in parenthesis is made necessary by some cases of launching-in-flight. See exp. 18, p. 71.

lessness of any psychological theory which suggests that it is past experience which plays the crucial part in setting up causal links.

The most interesting part about the theory, however, still remains to be discussed. A particularly satisfying feature is that it enables us to understand the *productive character* of the causal impression. It is this character which has always been taken by unsophisticated thinkers to be the essential feature of causality, as Hume pointed out in the following passages:

> 'Shou'd any one leave this instance, and pretend to define a cause by saying it is something productive of another, 'tis evident he wou'd say nothing. For what does he mean by *production*? Can he give any definition of it that will not be the same with that of causation? If he can; I desire it may be produc'd. If he cannot; here he runs in a circle, and gives a synonimous term instead of a definition.'[7]

and

> '. . . observations I have already made, that the idea of production is the same with that of causation. . . .'[8]

Here is a more recent passage to the same effect, taken from Durkheim:

> 'The first thing which is involved in the notion of the causal relation is the idea of efficacy, of productive power, of active force. By cause we ordinarily mean something capable of producing a certain change. . . . Men have always thought of causality in dynamic terms.'[9]

This productive character, however, involves a difficult problem, since if we follow the commonly accepted view and agree that empirical causality is merely the recurrence of regular sequences, the question arises as to where this special feature of 'productivity' comes from.

It is difficult to see how Hume's introduction of the idea of 'expectation' (i.e. the view that an event which regularly follows another event is therefore 'expected' to occur) can account for this productivity, nor why the fact that we expect something should enable us to go beyond a purely temporal relation.[10] The widespread acceptance of Maine de

[7] D. HUME, *A Treatise of Human Nature*, part III, section ii.
[8] D. HUME, ibid., section vi.
[9] E. DURKHEIM, *The Elementary Forms of the Religious Life*, 1915, p. 363.
[10] See Introduction, p. 8.

the dominant one being that of the motor object. This very fact excludes the possibility of any causal impression of braking. The speed of the object supposed to act as brake would clearly have to be less, at the moment of impact, than that of the other object. In that case the conditions of the experiment would be simply those of launching or entraining in flight; the more rapid movement would dominate the other on account of the hierarchy of speeds, and would necessarily play the part of 'cause'.

Lastly, to anticipate the discussion on qualitative causality in the next two chapters, we should note that the absence of any causal impression in the case of pure qualitative causality is what might be expected in view of the fact that in these cases no genuine ampliation is possible.

The theory of ampliation not only accounts for the absence of causal impressions in the negative cases; it also gives a basis for systematic construction of *paradoxical cases*. By this we mean experiments where the essential conditions for ampliation are fulfilled, but in such a way as to produce a causal impression which is at variance both with common sense and with our everyday knowledge of the laws of mechanics. Let us recall two typical examples of this; there are of course innumerable others.

The first example is that which occurs when object A is moving faster than object B and when both are travelling in the same direction; in this case a causal impression still occurs even though object B *slows down* after receiving the blow.[5]

The second example is that of launching experiments whose results show that the causal impression is more pronounced the slower the speed of object B in relation to that of object A.[6] The causal character is thus reinforced through the dominance of object A's movement becoming more emphasised, even though logically the efficacy of the cause ought to seem less rather than greater!

Negative and paradoxical cases clearly provide a crucial test for the theory of ampliation; and the result is confirmation at every point. A further advantage is that they provide a clear demonstration of the use-

[5] See p. 71.

[6] This is true, of course, only as long as the difference between the speeds is not great enough to bring about complete segregation of the movements. See. pp. 108 seq. and p. 119.

Now this sentence is surely an exact description of the process of reproduction, and is applicable quite literally to reproduction as it occurs in the organic world.

There, too, an evolution of the mother-organism results in a double existence which is associated at the start with a fundamental unity. A physiological duplication occurs which is similar, *mutatis mutandis*, to the phenomenal duplication. Moreover this duplication lasts from the moment when the new organism becomes distinct from the parent organism until it separates from it and has complete autonomy. This is exactly comparable to the way in which phenomenal duplication continues until the moment when the object moved passes beyond the limits of the radius of action.

The perception of causality is thus quite literally the perception of an act of production, or, to be more exact still, *an act of production immediately perceived*; it is not the perception of a simple 'dependence' (whether or not clearly defined) as found in cases of weakened causality such as triggering.[13]

We are now in a position to understand why it is that in our experiments certain particular conditions were found necessary in order to give rise to a causal impression. They correspond to the different characteristics of reproduction. In particular the hierarchy of priority (priority in time and importance) is clearly necessary, since reproduction is impossible without it.

Again, since production is a phenomenal 'given', the causal experience requires no further elaboration in order to acquire significance, but carries this significance already. The expressions which are used to describe this experience, far from investing it with a meaning or constituting an 'interpretation' of it, are indeed simply a translation into conceptual terms of what, at the phenomenal level, *actually does occur*. The causal impression is indeed the *source* of this meaning; and as was pointed out in the Introduction, it is the causal impression which plays a large part in giving ordinary objects the meaning which they have for us.

When we consider this remarkable character of productivity possessed by the causal impression, and of the undoubted importance of the causal impression in connexion with human behaviour, we may be

[13] All this of course applies in full only to the case of causality in the strict sense; in the case of immanent activity the reproductive aspect becomes reduced to the character of 'vague productivity' mentioned earlier.

Biran's theory can undoubtedly be explained by the fact that it seemed to provide a satisfactory solution to the problem.[11]

Now, however, the question arises in an altogether new form. The existence, in the world of 'external' experience, of causal impressions, possessing a character *sui generis* of productivity, results in a recurrence of the same problem, and shows at the very least that the character of productivity need not necessarily be borrowed from 'internal' experience. In that case we still need to discover how it arises.

The solution seems to me to present no difficulty. We need only take note of the following four points to be satisfied that ampliation of the movement involves a genuine production.

1. At the moment when ampliation occurs, there is the *appearance of a new event*, namely the change undergone by the passive object. This may be a simple displacement in space; it may be a forward movement, or it may be a change in shape.[12]

2. This new event appears *as a continuation of a previously existing event; it is the earlier event in an evolved form.* The essential feature of ampliation is that the movement (or change in shape) which previously belonged exclusively to the active object is *extended* on to the passive object.

3. The appearance of the new event does not involve the disappearance of the original one. The extension of the movement of the active object on to the passive one is something quite different from a total transformation of this movement, and quite different again from a mere substitution or division, since *the original movement continues to exist as such.* This is obvious in the case of entraining and its derivatives, but a similar situation is also found to occur in the launching cases, which are more puzzling. In these cases there is an apparent continuation of the movement of the motor object after the impact, and it is this which seems to bring about the displacement of the object moved, as was shown in Chapter VIII.

4. It follows that, at the moment when ampliation occurs, there is a *double existence*, that of the original event and that of the later one.

All these points can be summed up in one short sentence: the original process develops, and, without ceasing to be what it was before, 'becomes also' something else, distinct from itself.

[11] See Introduction, p. 11.

[12] This is true even in cases in which object B was already moving before it separated from object A (or before it was entrained by object A). In this case there is the appearance of a new event, because of the 'dividing off' which takes place at this moment (see p. 71).

research, seems a very compelling one, and it is desirable that we should pause for a moment so as to think out exactly the degree of 'objectivity' belonging to the causal impression.[14]

As a preliminary, the first thing which we should remember is that a large number of perceptual phenomena do not correspond to the action of specific stimuli in the sense of being simply their psychological counterpart. The fact that they appear as they do is conditioned by certain *combinations* of stimuli which acquire their character both from the intrinsic properties of the individual stimuli and from their distribution in time and space. It is a well-known fact that these combinations often do not show any observable resemblance to the phenomena involved; and in particular the properties of structural organisation, such as integration, segregation, 'belonging to', 'dependence on', etc., are clearly strangers to the world of stimuli, which, as far as the visual sphere is concerned, is nothing more than a collection of light rays operating independently of one another. In short, the rôle of the stimuli is to supply an impulse which determines the response of the receiving organism, which then reacts in accordance with the endogenous laws of its own functioning in constructing the phenomenal world.

Yet, as Köhler has aptly pointed out, this phenomenal world is in general much nearer to the physical world of objects around us and reflects its properties much more faithfully than do the combinations of stimuli, although the latter are the only intermediaries linking one world with the other.[15]

It follows that the 'objectivity' of an impression cannot be measured by its correspondence with this or that set of particular stimuli. Consequently the fact that in the case of physical impact no instrument can record the actual 'production' of the movement in no way implies a lack of objectivity in the causal impression as such.

Moreover, the fact that it is possible to produce 'illusions' of causality, as we have done in our experiments (where the two movements were produced independently of one another and there was no question of any 'real' launchings or entrainings), is not at all peculiar to the causal impression. We all know that illusions can be produced in any field of perception. This must necessarily be so, since not only can different

[14] To avoid all misunderstanding I should perhaps make clear that when I speak of 'objectivity' and 'illusion' in this context, these words are not intended in any 'ontological' sense, but refer only to what can be checked empirically.

[15] W. KOHLER, *Gestalt Psychology*, 1947, pp. 160 seq.

tempted to think of the phenomenon as having a unique position among the data of experience. There is no doubt, however, that such a view would be mistaken, and this is a point which requires emphasis.

In the first place, the causal impression shows obvious affinities with activity in other forms, so much so indeed that a careful study is needed to distinguish between them.

Secondly, the impression of production is made possible only by the occurrence of phenomenal duplication. It is because the physical movement of the passive object appears at the start in two forms that it can be seen as an 'extension' of the motor object's movement. In launching and in ordinary entraining it is seen both as a change in position of the passive object and as the movement performed by the active object. In propulsion it is seen both as a forward movement of the passive object and as a merely partial aspect of the active object's change in shape. In auto-locomotion, where the unity is more pronounced, it is the total undivided operation which is seen both as a change in shape and as a forward movement. We pointed out at the time (Chapter VIII) the relationship between these duplications and the curious phenomenon of double representation, of which many further examples are coming to light in the field of static perceptions. Once again it seems that the causal impression is not an entirely isolated phenomenon, but can be linked up with other psychological facts.

Moreover, as has been made plain from the very beginning of this book, there can be no doubt as to where in general this impression belongs. The problem of the causal impression undoubtedly has its place among the whole group of psychological problems concerned with the way in which perceptions are structurally organised.

One final point remains to be examined. It is an important one, since it concerns the whole significance of the causal impression.

From time to time the following objection has been raised: 'The result of your research is to show conclusively that the causal impression, a purely subjective creation, is an *illusion of causality*, to which we are subject when confronted with certain combinations of movements. This impression is nothing but a piece of deception, and gives us an erroneous picture of the physical world, since the *production* of the movement, or the *passage* of the movement from one body to another, cannot be recorded by any instrument.'

This argument, although it does not affect the positive results of our

kinetic energy of the ball which is the motor object,[16] and the impression of 'pushing away' corresponds to the *mechanical work done*, i.e. to the expenditure of kinetic energy in the displacement of the projectile.

Again, since the form that ampliation takes is that the 'pushing away' is the *prolongation of the impact*, it follows that it is the movement of the motor object which seems to be bringing about the displacement of the projectile; and thus throughout the two phases of the operation the fundamental unity of the process is maintained. In other words there is a *conservation* of process. Is not 'conservation of kinetic energy' here being genuinely transposed, in an appropriate form, to subjective experience?

Now conservation of process is a characteristic of the causal impression even when the speed of the projectile is less than that of the motor object (pp. 108 seq.). In the same way conservation of energy is said to take place even in cases where kinetic energy is lost after the impact, e.g. as a result of friction or lack of elasticity. It should be emphasised once again that this is obviously the case which most frequently occurs in nature and is also that which gives the clearest causal impression (p.108).

Similar parallels are also to be found in a whole series of details. Thus attention was drawn on p. 134 to the appearance of *inertia* of the projectile in cases of launching.

There is a further parallel in the fact that the causal impression is more pronounced when the difference between the speeds of the objects before the impact is more marked (see the experiments on launching-in-flight, pp. 69 seq.). This corresponds to the fact that the efficacy of the physical impact, measured in terms of the changes of speed which follow it, is greater, the greater the difference between the speeds at the moment of impact.

Again, when experiments were performed in which the speed of the projectile was greater than that of the motor object, the causal impression appeared only in cases where the ratios of the speeds were within a certain range. These limits were found to coincide in a remarkable way with those required by the laws of mechanics (note 8, pp. 111–12).

Finally, we saw that the causal impression is directly dependent on the relative direction of the paths followed by the two objects. When the

[16] In this case the impression of 'force' attends the motor object when it is *in action* and genuinely corresponds to kinetic energy. But this does not occur in the case of a simple impact where there is no change in the object struck. It would therefore be a mistake to link the impression of 'force' with the concept of 'power to do work', as was pointed out on p. 110.

combinations of stimuli give rise to similar impressions, but also similar combinations of stimuli can have their origin in different physical conditions (as was the case in our experiments).

Fortunately, however, we are so made, and the world is so made, that *in normal conditions of everyday life* there is generally some degree of correspondence between our impressions and the things or physical events which give rise to them. When an object appears to us like a cube, it usually *is* a cube, and when an object appears to us to be moving, it usually *is* moving. 'Illusions' are relatively rare, or at least they are not so important in practice as one might suppose, considering the ease with which they can be produced in laboratories. Moreover, the very fact that we can live and act in a way adapted to our environment shows that there is a very wide correspondence between the phenomenal world and the physical world.

Thus the fact that in general our perceptions have objective validity does not exclude the possibility of illusion, and the fact that in some conditions there occur illusions of causality certainly does not prove that our causal impressions in daily life are illusory.

It still remains, of course, to consider whether there is any sort of parallelism between these causal impressions and the physical events which normally give rise to them, e.g. the impact of one billiard ball on another.

A fundamental point needs to be stressed here. It would be quite wrong to try to discover the answer to our question by considering only the physical *movements* of these objects, for the causal impression is *something quite other than a mere perception of movements*. Thus, as was pointed out earlier (pp. 24 and 63), the impact itself is an event of a special character from the phenomenal point of view, having special properties. One such property is that of 'force', which becomes accentuated as the difference between the speeds increases, and is sometimes such that there is a tendency to refer to it as '*vis viva*' (p. 109). We should remember, too, that we see the impact drive away the projectile and thus perform a quantity of 'work'. Many examples of this kind could be given; we have met them continually during the course of this book. All of them are suggestive of concepts belonging to the field of *dynamics*; and it is clearly in this field that we should seek the answer to our problem.

As soon as we look at things in this way, the solution immediately becomes obvious. The impression of 'force' clearly corresponds to the

QUALITATIVE CAUSALITY

In everyday life we frequently come across instances of physical causality which are very different from those discussed so far. These are cases where the displacement of an object in space does not play an exclusive part, and where the events which act as cause or effect, or as both, are *appearances* or *disappearances* of an object, or *changes in quality or intensity of its properties*. This is what is happening when we see e.g. an iron bar becoming red-hot in the fire, the water in a pan beginning to boil on reaching a certain temperature, sheets drying in the wind, or a piece of sugar dissolving in water. All these different kinds of event will be treated as changes in quality, and to refer to them I shall make use of the term 'qualitative causality'.

It often happens, as in the examples just cited, that the action of the cause is slow to operate. There is a fairly long interval between the time when it first starts and the time when its effects become apparent. In these cases, therefore, there can be no question of the causality being actually perceived.

There are many other cases, however, where the succession between cause and effect is immediate, and the question of the causal impression arises in the same way as it does for mechanical causality. We may quote as examples the change in the look of a country scene and the appearance of shadows when the sun comes out from behind the clouds, the change in colour of a piece of cloth when it is damped, the change in colour which takes place when two different liquids are mixed, e.g. coffee and milk, or the change in colour which occurs in the case of certain chemical reactions.

Further examples are the appearance and disappearance of the light when the button of an electric torch is pressed or released, the appearance of a flame at the moment when a match comes into contact with the red-hot embers in a stove, the production of noises or ringing sounds by the striking of a bell or a piano key, or the vibration of the windows in a house as a cart goes down the street.

In addition there are many other cases where physical actions of a mechanical kind appear on the psychological plane as qualitative

path of the projectile is not in a direct line with that of the motor object, the impression is weakened, and it disappears completely when the paths of the objects are at right-angles to each other (pp. 101 seq.). Now it is well known that the same holds in mechanics; the work achieved by a force is zero when the point to which it is applied is moving at right-angles to the direction of this force.

In short, in spite of the many contradictions mentioned in the course of this book, there is an impressive amount of agreement between the laws of mechanics and the properties of the causal impression. The correspondence between them is indeed so extensive that anyone not very familiar with the procedure involved in framing the physical concepts of inertia, energy, conservation of energy, etc., might think that these concepts are simply derived from the data of immediate experience, and conversely that the 'production' which characterises the causal impression should be regarded as something physical.

In view of all these considerations we may conclude that the perception of causality is as 'objective' as all other perceptions. Just as in normal conditions of everyday life the impression of an object's movement usually corresponds with a physical movement and is 'brought about' by it, so *the impression of launching (or of entraining) corresponds usually with the work of a mechanical force and is 'brought about' by it.*[17] If we want to put this into everyday language, i.e. to describe the perception not in terms of its phenomenal content but in terms of the 'physical object' apprehended, we can say that the causal impression is *the perception of the work of a mechanical force*, just as the impression of the movement of a car is the perception of its displacement in physical space.

In closing these chapters on the impression of mechanical causality, I cannot do better than quote here the conclusion reached by a discerning colleague of a philosophical turn of mind, who had been present at a series of demonstrations. 'What it amounts to,' he said, 'is this. You start off with an illusion, and use it to prove that causal impressions are real and objective!' These words contain the full justification for the method followed in our research.

[17] The reason for this is clear. Normally it is only when such mechanical forces are operating that there is the requisite combination of physical *movements* for producing the causal impression; similarly it is a physical movement which normally provokes the successive stimulation of different points on the retina, and thus gives rise to an *impression* of movement.

CHAPTER XV

Movement of One Object linked with Qualitative Change in Another

It should be made plain at the start that, when movement of one object is linked with qualitative change in another, it is possible for a perfectly clear causal impression to occur, as is shown by the first three experiments described below. Our most experienced subjects are absolutely definite on this point. A causal impression, however, is not the general rule. While it may sometimes occur in the form of launching and sometimes in the form of triggering, often it is not present at all, and between the events there is simple contiguity or temporal co-ordination.

Exp. 73.[1] Object B alone is present, and is motionless. Object A appears suddenly beside it, and at this moment B begins to move and withdraws from A for a distance of 5 or 6 cm.

I have already mentioned this experiment in connexion with the influence exerted by the amplitude of the movements. Perfect impressions of launching were observed by four experienced subjects out of

[1] For this experiment and those which follow the disc method is possible, but, if we use it, it means that when the objects are made to appear and disappear they do so by moving up and moving down in the slit. For the speeds ordinarily used this is not noticeable, but in order to eliminate a possible source of error we preferred to use the projection method, which enabled us to make the objects appear or disappear instantaneously.

To produce the required result, one of the projectors was fixed, and was fitted with a drop-shutter at the point where the beam of light was narrowest. It was connected electrically with the other projector which remained mobile.

In exp. 73 the drop-shutter was in front of projector A, and when it was raised it started projector B moving. In exp. 74 it was in front of projector B, and was released when projector A reached the end of its journey.

When it was simply a question of making one of the objects appear or disappear, the frame of the drop-shutter was fitted with an opaque screen; but when we needed to produce a change of colour or intensity in the object, as we did for some experiments, it was fitted with two different screens of coloured gelatine.

For all experiments, unless it is otherwise indicated, the objects were bright-coloured circles, 30 mm. in diameter; the speed of movement was 30 cm. per sec., and the observation-distance was 1·50 metres. The succession between the events was immediate, the interval being no more than a few milliseconds.

changes, e.g. the appearance of a crack in a vase which has been knocked over, the breaking of a plate when it falls to the ground, or the bursting of a soap bubble when it is touched.

Finally it would not be entirely unreasonable to include in the same category the cases of propulsion which we examined earlier, on the grounds that changes in shape can be considered as qualitative changes. This method of classification, however, does not really seem justified, since the causal impression of propulsion, as we saw, is dependent on its *kinematic* character as such, and is directly linked with mechanical causality in the strict sense, both theoretically and in respect of the conditions in which it is produced.

It is clear, then, that qualitative causality presents a problem of its own. Now if it is true even in the field of mechanical causality that incidental observations are not sufficient to demonstrate that there is a specific causal impression, this is all the more so in the case of qualitative causality. It is therefore essential to have recourse once again to experimentation.

A large variety of experiments were performed in which an attempt was made to come as close as possible to the sort of everyday conditions in which we consider one event to be united with another by a causal link.

Some of those attempts will perhaps seem rather naïve after the theoretical developments described in the first part of this book, and they in fact belong to the time before the theory took shape. I do not think, however, that they are completely without value, since, although they led to failure, we are enabled as a result to give a more precise account as to why this failure occurred.

The experiments to be described are of two different kinds, which will be examined in turn. In the first group a qualitative change was linked with the movement of an object, the movement being similar to those which play a part in experiences of mechanical causality; in the second group both the changes were qualitative.

six; the other two saw only a triggering. When the experiment was repeated, however, even the original four showed some variation in their responses. The same experiment was performed with fifteen new subjects; the Launching Effect was reported in seven cases, and for the remainder there was simple temporal contiguity.[2]

In this case, as in cases of ordinary launching,[3] the place where object A appears is very important. In the last experiment A appeared beside B and in contact with it, on the other side of it from the side on which B's movement takes place. If the experiment is arranged so that A appears immediately above or below B, the Launching Effect disappears; five experienced subjects on whom this was tried had an impression of triggering.

Exp. 74. Objects A and B are motionless and 5 or 6 cm. apart. A begins to move and goes towards B. At the moment when it touches B, B disappears abruptly.

Exp. 75. Objects A and B are motionless and 5 or 6 cm. apart. A is a white disc, while B is red. A begins to move and goes towards B. At the moment when it touches B, B changes colour abruptly and becomes either green or white like A.

These two experiments can be considered together, since they gave similar results. In the first experiment three of the experienced subjects had the impression that A drove B away, the fourth saw a triggering, and for the fifth there was only temporal contiguity.

Of the thirteen new subjects, five received the impression that A drove B away, two had an impression of triggering, and for the other six there was simple temporal contiguity.

In the case of the second experiment, three trained subjects had the impression that A 'caused B's colour to change' or 'drove away the red colour'; the other mentioned only a triggering.

As for the new subjects, two out of eleven spoke of a causal influence, while for the nine others there was only temporal contiguity.

These experiments are the only ones among those considered in this chapter which gave rise to characteristic impressions of launching. It

[2] A special phenomenon can sometimes be seen in this experiment and the following ones; a time-shift occurs, and the event which objectively comes second appears to take place before the other one. Thus in exp. 73 some subjects said that B moved off and that another object then appeared in its place. This impression was received only by the new subjects.

[3] See exp. 33, p. 101.

sion was of temporal contiguity without any internal link between the events.

The following experiment is of a similar type to the previous one.

Exp. 79. Object B, a white circle, stands out in the centre of a large red square of side 50 cm. which forms object A. The colour of this square suddenly changes and becomes green. At this moment B performs a movement similar to that in the previous experiments.

When this experiment was carried out with five experienced subjects, one of them had a vague impression that the movement depended on or was triggered off by the change in colour. In the case of the other four there was once again nothing but simple temporal coincidence.

The absence of any causal impression in these four control experiments fully agrees with what we might have expected *a priori*. If it is true that the gamma movements which normally occur when an object appears are equivalent to a dilatation, and that those which occur when it disappears are equivalent to a contraction, then in the conditions which we set up, and in expts. 76 and 77 in particular, the objects must have been moving in opposite directions. This, as we know, is not compatible with the production of an impression of mechanical causality (see also exp. 83, p. 242).

We must therefore conclude that this type of experiment has no bearing whatever on the question of qualitative causality.

In another series of experiments a visual event, e.g. the movement of an object, was linked with a noise. This is at first sight one of the most obvious cases of qualitative causality, at any rate to judge from our daily experience of the noise made e.g. by the shutting of doors, the falling of objects, the clapping of hands, etc. Our purpose was to examine these situations closely; and we tried out a large number of experiments in which noises were made to coincide with visual events of many different sorts.[5]

Thus if we take as our starting-point the principles established in the case of mechanical causality, and if we assume that the apparent movements which we are studying play a part similar to that of objective movements, it is then possible to devise experiments of a kind in which no causal impression can occur. Here are some examples.

> Exp. 76. At the start of the experiment, object A is motionless. Then it moves off, and after covering a distance of 5 or 6 cm. comes to a halt. At this moment object B appears abruptly beside it at its ordinary starting-place in the launching experiments.

This experiment was carried out with five experienced subjects, and has been repeated with them on many occasions. The results have been very variable, but the most typical one was the impression of a *meeting* between the two objects. (This result was mentioned by all subjects at one time or another; the word 'meeting' was used quite spontaneously by them, and they were in no way influenced by one another.) The two objects seemed to them to *arrive at the same time* at the point of contact. Apart from the impression of meeting, the result most often obtained was that of simple temporal co-ordination; B appeared at the moment when A stopped. The comments which the subjects made seem to show that this happened when the apparent movements failed to occur. One subject said that object B seemed to *come out of* object A or overtake it at the moment when it stopped, although he did not receive any impression of active expulsion. One subject said once that he had a vague impression of triggering, but he was not sure about it.

> Exp. 77. Objects A and B are touching each other. Object A disappears abruptly, and at this moment object B begins to move, and withdraws for a distance of 5 or 6 cm. from the position formerly occupied by A.

> Exp. 78. Objects A and B are touching each other. Object A is red, object B white. A suddenly becomes green; at this moment B begins to move and withdraws for a distance of 5 or 6 cm. from A.

There was never any impression of launching in either of these experiments; the movement of B always seemed autonomous. At most a vague triggering was seen by some of the experienced subjects. One of them said, for example, 'It is as though A's disappearance lifted a catch, which had been holding B back and preventing it from starting' (i.e. there was intervention by an intermediary object). The last experiment was repeated with eleven new subjects; in every case the impres-

of the object) two observers out of eleven said that it was the noise which drove it away; in case (ii) (appearance of the object) two subjects out of four said that the visual event made the noise, and in case (iii) (the flickering case) one in six said the same. The passing of one object over the other (case v) gave only negative results, and when a noise occurred at the time when the object halted (case iv), only two subjects out of nineteen declared that the noise had any influence on the movement! In most cases the reports were either of 'independent' events or of events simply connected in time.

It often happened, however, that an indirect relation was set up between these events through a third object acting as intermediary. For instance observers spoke of 'a screen which made a noise as it passed in front of the object', 'the noise of the switch putting the light on', and 'a box which shut and made the object disappear'.

In the light of these results we may wonder whether in the positive cases just mentioned (seven out of forty-six) there was genuinely an impression of influence. The explanation may rather be that these observers were less explicit than the others, and what they said did not adequately reflect the impression received. This supposition seems all the more justified since in four cases out of the seven in which influence was mentioned the noise was said to 'bring about' the visual change, and this surely makes no sense unless the word 'noise' is a short way of saying 'the apparatus which makes the noise'. In one case, which of course we counted as negative, an observer said (these are his exact words), 'What you call the noise is really the switch; I can see a causal connexion; the switch causes the object to disappear.'

We decided that the only safe conclusion was to regard these experiments as entirely negative.

In the following experiments, a second object was introduced.

Exp. 81. Two circles of light, 50 mm. in diameter, are situated 35 mm. away from each other. One of them begins to move, goes towards the other at a speed of 30 cm. per sec., and stops after coming into contact with it. In another version of the experiment the object rebounds after the impact. In both cases the noise occurs at the same time as the contact.

This experiment was tried on six subjects only, four of whom were experienced. The results showed considerable variation. In some cases the events seemed independent, while in others the impact seemed to 'produce' the noise. For present purposes, however, the most important

Before these experiments are described in detail, however, two points should be emphasised.

First, no useful purpose would be served by introducing into this experiment a systematic variation of temporal intervals, as we did, for instance, in our launching experiments. We should in that case have come up against the well-known phenomenon of time-shift which occurs when impressions are of completely different kinds. In order to ensure a constant phenomenal order of succession, the intervals have to be so large that the result is a complete segregation of the two events.[6]

Secondly, throughout these experiments a remarkable thing happened. We had taken the precaution of not informing the subjects what the purpose of the experiment was. All we said was, 'Look at the screen and describe everything which takes place.' Now, with one or two exceptions, no observer, unless prompted, made any mention of the noise! When we asked them whether they had heard it most of them replied that they had, but added that it had nothing to do with the visual impression as such. We then began the experiment again, the instructions being this time: 'Please notice whether there is any connexion between the noise and the visual event.' As we shall see, when this suggestive wording was used, the results varied according to the type of visual stimulus involved.

Exp. 80. We may group under this heading a whole series of experiments which gave similar results. The visual object was a circle 3 to 5 cm. in diameter, and when it moved it had a speed of 30 cm. per sec. The observation-distance was 2·50 metres. The visual changes, which occurred 20 milliseconds before the noise, were as follows: (i) the object disappeared, (ii) it appeared, (iii) there was a momentary change in its brightness (the object being motionless in all these three cases), (iv) the object moved and then stopped abruptly, (v) one object moved, and passed over another which was stationary.

Throughout all these experiments, despite our use of suggestion, it was only in exceptional cases that observers used expressions implying that one event had an influence on the other. In case (i) (disappearance

the visual objects were projected so that they could move at the point where the hammer struck. The apparatus was put on its own in the centre of the room, and in these conditions the localisation was satisfactory.

[6] The threshold in our experiments for the appearance of succession was about 5 or 6 centiseconds.

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We decided that the only safe conclusion was to regard these experiments as entirely negative.

In the following experiments, a second object was introduced.

Exp. 81. Two circles of light, 50 mm. in diameter, are situated 35 mm. away from each other. One of them begins to move, goes towards the other at a speed of 30 cm. per sec., and stops after coming into contact with it. In another version of the experiment the object rebounds after the impact. In both cases the noise occurs at the same time as the contact.

This experiment was tried on six subjects only, four of whom were experienced. The results showed considerable variation. In some cases the events seemed independent, while in others the impact seemed to 'produce' the noise. For present purposes, however, the most important

point is that for more than one observer the 'production' of the noise was much more clearly marked *when rebounding took place.*

Exp. 82. This experiment is identical with the previous one, except that the second object itself begins to move at a speed of 6 cm. per sec. after the impact. The result is a Type-experiment of launching, performed in optimum conditions.

Twenty-one people, eighteen of whom were new subjects, took part in this experiment; twelve of them, or 57%, stated, when we asked them specifically, that the impact produced the noise. Of the others, six as the result of a time-shift said that the noise came first; and from one of them we once more had the claim that the noise was the cause of the movement. To eight subjects the events appeared to be independent.

Those are the facts. What is their significance? The problem requires close study, since, as will be seen later, these last two cases are the only ones, out of all our material on qualitative causality, in which the wording used by observers gives any ground for believing that there is a genuine causal impression.[7]

Before we reach any conclusion on the matter there are a number of points which require to be taken into account. The fact mentioned just now, that there was in general no spontaneous mention of noise, is certainly significant. It shows that for the subjects who were not warned the noise and the visual event were not connected. This was so in spite of the favourable conditions produced by the spatial and temporal coincidence of the events, and despite also the similarity of temporal properties, which I shall discuss in a moment.[8] Since the events were dissimilar, a link of any kind between them seemed difficult to establish. Subjective factors making for integration, in the form of an attitude of expectation arising as a result of our suggestions, must presumably have intervened and added their influence to that of the objec-

[7] It seems likely that there is a comparable situation when the noise is made to occur at the same time as impressions of activity, or at the same time as impressions of causality in the tactile-kinaesthetic sphere.

[8] One of the observers produced the interesting comment, 'It was not possible to have a causal impression, since what I saw was only an image, and an image cannot produce a sound.' It may be that the phenomenal difference between the 'real' character of the sound and the 'image' character of the visual object helped to bring about the segregation of the two events. We should note, however, that this cannot be the main reason for the segregation, as is shown by the launching experiments which were performed in similar conditions. See pp. 83 seq.

tive factors. Even so it is noteworthy that the link mentioned was often an indirect one (e.g. the noise of the apparatus).[9]

The similarity of temporal properties plays an important part. This is clear from the fact that the impression that the visual event 'produced' the noise was much more marked when both events were only momentary, as in the cases of rebounding and launching, than it was when the objects stayed permanently together after the impact, while the noise was over in an instant. As a cross-check it is possible, in the launching experiment, to make the noise last indefinitely after the impact. This is done by means of a trembler, and the result, once again, is to favour segregation.[10]

In view of all this, one point is clear. In the experimental situations which we set up, the factors of integration operated to link together these impressions of different sense-modalities in a less automatic and compelling way than we might have expected. This inevitably makes it a matter of some doubt whether in ordinary life there can be a spontaneous 'causal impression' linking up an impact with the noise which goes with it.

From the point of view of theory, however, there is a more important consideration. To produce the impression of mechanical causality it was necessary that the events should be successive; and, as we saw in the case of delayed launching, the impression of causality was still possible even after an appreciable time-lag. In the present case, however, what is required is that the events should be *simultaneous*. Unfortunately, systematic experiments cannot be performed to test this, because of time-shifts, and we have to limit ourselves to the verbal reports of observers. These, however, leave us in no doubt. In the experiments which involve impact or launching they constantly imply that the noise came too soon or too late, that it did not occur at the moment when the

[9] Periodical repetition of the stimuli is favourable to the integration of the two events, since it leads to a state of expectation. This explains some of the results which can be observed in the case of the experience of apparent simultaneity, or what I have called the 'complication' experience. See on this subject A. MICHOTTE, Nouvelles recherches sur la simultaneité apparente d'impressions disparates périodiques, *Études de Psychologie, Louvain*, I, 1912, p. 158.

[10] This experiment resembles the familiar situation in which a momentary impact causes reverberation in an object such as a glass or a bell. In these cases the sound clearly belongs to the object itself; yet we attribute its beginning to the impact. It seems, therefore, that we are influenced here by the complex conditions of situations in everyday life; and in these cases it is very likely that a large part, and perhaps a crucial one, is played by past experience in leading us to make a causal 'interpretation'.

objects made contact, and that it was *because of this* that the impression was not really a *causal* one. Indeed, it is only in cases where the two events appear to be simultaneous that we feel inclined to say that the impact is the cause of the noise.

Now in the ordinary way the impact and the noise appear as impressions lasting only for a moment. When the contact between the objects is maintained, or when the noise continues after the impact, it is still only the fact that they begin simultaneously which is relevant.

Yet it seems obvious that the simultaneous occurrence of two momentary events must by definition exclude any possibility of a phenomenal production of one by the other, for the impression of 'production' presupposes an evolution, as was pointed out in connexion with the theory of ampliation and also in connexion with propulsion. The link between the two events cannot in this case be one of production, but only one of 'belonging'[11]; in other words the noise must appear as a *property* of the visual event.

If this is true, however, how is it that observers use expressions which seem to imply causality? We might attempt an answer by saying that it is a verbal habit, and also that the expressions used relate to the physical world, where it is clearly the impact which produces the noise. This solution, however, is somewhat simple-minded and not very convincing, since 'It is the impact which is making the noise' accords better than any other description with our feelings about the situation.

Instead of giving this answer, we should, I think, take into account the fact that the so-called 'production' of the noise was mentioned regularly only in connexion with experiments involving impact or launching, and that it was certainly attributed to the impact as such. Now, as we saw at the beginning of this book, the impact displays a clear character of activity; and it follows from what has been said that the noise must appear as a property of this activity and must be a particular feature of it. In short, there must be a 'noisy' activity. If this is right – and I think it is – then to say of an object that it *makes* a noise when it strikes another object is like saying that an object *gives* a blow to another object. As was pointed out on p. 24, no causality is involved here. All that the expression implies is a qualification – an account of

[11] Since the visual objects and the movement are present before the noise is produced, the noise must have a subordinate status in relation to them; it is for this reason that in the last few experiments the noise normally belongs to the impact (and not the other way round).

the *sort* of operation which is being performed by the object that is in action.[12]

[12] It is interesting to note that among the examples of 'unmistakable' causal impressions mentioned by Duncker and Metzger (cf. Introduction), there is that of a light going on at the moment when a door is shut. If what has been said above is right, then a causal impression certainly ought *not* to occur in these conditions. This mistake on the part of investigators who are good observers and astute thinkers illustrates in a remarkable way how people can be misled by incidental observations, and how necessary it is in matters of this sort to have recourse to experimentation.

CHAPTER XVI

The Linking of Qualitative Changes in Two Objects

In the experiments which will be described in this chapter all objective changes in position were removed, and as a result, it seems, the apparent changes in position with which we were concerned in the last chapter disappeared also; at any rate subjects never mentioned them. On the other hand gamma movements of expansion and contraction occurred again in some cases, and also stroboscopic movements, as we shall see.

Exp. 83.[1] The objects are two circles of light, 30 mm. in diameter. They appear side by side, one after the other (with an interval large enough for the sequence to be noticed). Alternatively the two objects are both present, and then disappear one after the other.

In this case gamma movements occurred, and were of such a kind as to exclude *a priori* any possibility of an impression of mechanical causality. Sometimes what happened was that the two objects remained segregated, and there were thus either two dilatations or two contractions. (This meant that when one object appeared to move one way, the other object appeared to move the opposite way; they either went to meet each other or drew away from each other.) At other times, however, the object formed a whole – a figure eight on its side; and in these conditions a different impression was received, that of a gradual appearance or disappearance of the whole shape. In neither case was there any causal impression, and the only point of interest in this experiment is that it indirectly confirms what was said above about the relations between gamma movements and mechanical causality.

In the following experiment, on the other hand, the gamma movements might have seemed likely to favour the appearance of a causal impression.

[1] In this series of experiments about ten subjects took part, all of them experienced. The experiments were performed by the projection method (see the note on p. 231) with both projectors fixed, and each fitted with a drop-shutter. The drop-shutters were connected electrically in such a way that the operation of the first released the second either immediately or after an interval.

Exp. 84. Object B is present, and is motionless. A suddenly appears beside it, and B then disappears.

On this occasion we might have expected to see a Launching Effect, since A, as it expands, goes to strike B, and B, by reason of its contraction, withdraws from A. The actual result, however, is something quite different. There is a stroboscopic effect, similar to that found when an object in one part of the visual field disappears and immediately afterwards there appears another similar object in a different part of the field. In other words we simply see object B change its position. This phenomenon continues to appear even when the interval is appreciable; there is therefore no question of any causal impression.

There seemed good reason to hope that all kinds of apparent movement could be eliminated, and that changes of a purely qualitative kind could be produced if the only variation made in the objects was a change in colour. This procedure, however, does not fully succeed in eliminating apparent movement, as the following experiment shows.

Exp. 85. Object A, a green circle, is placed at the side of B, a red circle. A changes colour abruptly, becoming yellow; immediately afterwards B becomes blue.

In a variation of the experiment, there was a simple permutation of the colours, A becoming red and B green.

The most frequent impression was one of a succession of independent events. When there was permutation of the colours, however, a rather curious phenomenon occurred. At least four subjects noticed a clear stroboscopic effect involving only colour.[2] It seemed to them that it was the *colour* which passed from one object to the other, and this phenomenon was apparent even when the objects were 4 or 5 cm. apart. In point of fact it was only the green colour which changed its position and seemed to pass from A to B. It was a little brighter than the red, and it is quite possible that the difference in brightness determined what occurred, since if this difference becomes more marked the usual stroboscopic effect appears, giving the impression of a movement of the *object*.

A final experiment was carried out, the purpose of which was to integrate the two objects in a whole with a clearly marked hierarchy.

Exp. 86. Object A was a red circle 250 mm. in diameter, in the centre of which was object B, a small blue circle 30 mm. in diameter.

[2] A similar phenomenon was also observed when there was permutation of the microstructure of two objects.

A suddenly changed colour and became green, and B then changed in its turn and became yellow.

The unity of the whole was so strong here that the observers had the impression of a single object, and as a result several subjects received the impression that the changes were simultaneous. Increasing the interval served only to ensure that the changes were phenomenally successive; they still seemed to be changes in a single object.

All the experiments examined in the course of this chapter and the previous one were conceived on the same principle. Our purpose was to bring about a spatial and temporal contiguity between two successive events, of which at least one had to be purely qualitative, and to see if there was a causal impression in these conditions, which according to some schools of thought are decisive.

As we have seen, however, complete elimination of the movement element is extremely difficult, at least when the events in question are both visual ones. The result is to make us revise our views as to the conditions in which 'qualitative' causality is to be found, since the causal impression which sometimes appears is clearly one of mechanical causality, and is bound up with gamma movements, while at other times any kind of causality is ruled out because of the presence of stroboscopic movements. Thus the total amount of purely qualitative material remaining from all the experiments described is extremely small. There are the impact-noise experiments, and a few visual experiments, in particular those in which the gamma movements were not favourable to causality.

In these cases no trace of causality was found. Moreover if the experiments were performed several times over (as is easily possible by means of the disc method), this did not affect the results in any relevant way, in spite of the fact that it naturally gave rise to a state of expectation. The main result of repetition was to make or strengthen the link between events which would normally have seemed unconnected. The impact-noise case provides a typical example of this. Mere temporal juxtaposition can in this way be turned into a 'belonging', but we never saw any instance of its evolving into 'dependence', still less of its being transformed into a link involving production.

Of course the question arises whether the absence of any causal impression in these cases is due to the nature of the events which we tried to link, and whether, if we selected our material more judiciously

and made use of what we have learned about mechanical causality, positive results would not be obtained.

In order to answer this question, some further experiments were devised. As a starting-point we made use of the fact that the causal impression of launching appears when the approach of one object is immediately followed by the withdrawal of another. We therefore tried by various means to produce similar situations in the qualitative field. The three following experiments provide examples.

Exp. 87. The two objects are circles of light 5 or 6 cm. in diameter, set side by side on a dark background. One of them (object A) is a red of very low brightness and very de-saturated; the other (object B) is a red of moderate brightness, with almost the maximum saturation. At a given moment object A takes on exactly the same shade as object B, and there is thus an 'approach' of the two colours. Object B then in its turn brightens and becomes a pale pink, so as to be distinctly brighter than A. Thus it 'withdraws' from A in respect of brightness. At the first change the brightness of A 'goes towards' the brightness of B; at the second the brightness of B 'goes away from' the brightness of A.

The ratio of intensities of light at each change was about 3 or 4 to 1.

The two changes were instantaneous, and the time-interval between them varied in different cases. The observation-distance was 2 m. or 2·50 m.

The results of this experiment differ according to the interval between the changes, and according to whether the two objects remain distinct or are joined together to form a horizontal 8.[3] But there is never any causal impresssion.

When the two objects are distinct, and the second change follows the first immediately, we simply see the objects take on a lighter colour one after the other. The two changes are independent, and the fact that at a certain point there is equal objective brightness is not even phenomenally apparent. If, however, a sufficiently large time-interval is introduced, the result is a sequence of three stages, viz. (i) object A takes on a lighter colour; (ii) there is a moment of uniformity, and (iii) object B takes on a lighter colour.

When the whole is seen as a unity and there is no time-interval, the impression is one of the object taking on in general a lighter colour; it is somewhat as though it had been covered with smoked glass which is then drawn back, disclosing A and B in turn. In these conditions there

[3] This kind of organisation is favoured when observers look at the objects with the purpose of comparing them.

is no stage of equal brightness, unless there is a time-interval, in that case there are again three stages, viz. (i) there is a complex figure, in which the contrast between its internal parts – i.e. the difference in brightness – is clearly marked; (ii) this figure becomes uniform and simple, and (iii) it again becomes complex, displaying a fresh contrast which gradually becomes established between the constituent parts.

This character of evolving possessed by the internal structure is still more striking in the following experiment, because the integrative factors are accentuated.

Exp. 88. Object B was a ring set between a circular area at the centre and another ring at the periphery which together formed object A. The three parts of the figure were concentric, and there was immediate contact between ring B, and the two parts of A on either side of it.

At the beginning of the experiment ring B was a dark pink, and the rest of the figure was a medium shade of pink; then the ring became the same colour as the central and peripheral areas. Thirdly, these in turn took on a lighter colour.

The apparatus used for this experiment was a Lummer-Brodhun photometer. The intensity of the light could be altered either abruptly or gradually by means of a device which need not be described in detail here.

Six experienced subjects took part in this experiment, and they each made a large number of observations. The results were much the same as those for the previous experiment.

When the succession was immediate, and the modifications in the colour were made abruptly, the impression was that of an alteration in the whole object. In spite of this, the change-over from one impression to the other was not immediate. There was an intervening stage, somewhat difficult to describe, but certainly not consisting of a period of equality.

When the modifications were gradual the change-over gained in importance, and the stage of uniformity was sometimes quite clear. To some subjects the whole area seemed entirely covered with a thick mist, which then cleared and disclosed the new figures. Others saw a grey-coloured veil which came over the whole object.

It is a distinctive feature of these two last experiments that the change, whether abrupt or gradual, gives no impression of *leading to* uniformity or *departing from* it.

Whether the two objects were clearly segregated or were integrated in a single whole, in neither case did the increase in brightness of one

object take the phenomenal form of an 'approach', nor even of *an increase in similarity* to the colour of the other. Conversely, the increase of brightness in the second object did not appear as a 'withdrawal' or *a decrease in similarity*.

Yet another experiment was carried out, this time in the auditory field, by the use of an appropriate series of sounds. An attempt was made to produce what may be called 'qualitative movements'.

It is clear that distinctive 'ascents' and 'descents' can be produced in this field by a gradual variation (whether continuous or discrete) in the pitch of a series of sounds. This gives an impression which is obviously similar to that given by movement; indeed the similarity is much closer than in cases of change of colour or brightness. Let us now suppose that, at the same time as this series of sounds, a permanent sound is produced – first a permanent sound different in pitch, to a greater or less extent, from the starting-note of the series, and later a permanent sound different in pitch from its final note. In this way, so it might seem, purely auditory impressions of 'approach' and 'withdrawal' could be obtained. The result would be to produce conditions comparable to those of the Launching Effect. This was attempted in the experiment described below.

Exp. 89.[4] Two notes are sounded simultaneously, e.g. the E above middle C (object A), and the C above middle C (object B). At a given moment the E disappears and is replaced by a series of sounds gradually rising as far as the B above middle C. At this moment the series stops and note B is then heard continuously. At the moment when note B is first sounded, however, the C above middle C disappears in turn, and in its place there is a new continuous ascent starting from the C above middle C and continuing as far as top G.

In this experiment there are thus two sounds which remain 'motionless' (i.e. do not change pitch) at the 'centre'. Now if these sounds are near enough to each other in pitch, the most usual impression is that of a single total ascent which at one point makes a 'jump'; when the distance between the 'motionless' sounds is greater, the impression is given that the second ascent is as it were an 'echo' of the first, a repeat

[4] For this experiment we used (i) successions of discrete notes, a quarter of a tone apart, in an ascending scale, and (ii) a continuous rise in pitch produced by means of a Stern variator. The extent of the rise was, of course, different on different occasions, as also was the interval on the scale between the sound which formed object A and that which formed object B.

in a different part of the scale. Thus the impression given in the first case is similar to that of the continuous movement which occurs when the launching experiment is performed with reduced visual acuity (Chapter IV, pp. 47 seq.), and the impression given in the second case reminds us of the 'Relay' Effect (Chapter IV, p. 57). In the latter case the second event appears either as a continuation of the first or as a repeat version of it. The 'motionless' sounds at the centre fade entirely into the background and have no subjective importance.

Sometimes, however, the factor of harmony intervenes and makes the 'rise' seem like a progressive change of 'chords' rather than a simple ascent of notes. In this case the motionless note and the changing note form a 'whole', and it is the 'whole' which changes.

Whatever else happened, the 'ascent' of the sound was not 'polarised', any more than was the change of colour in the previous experiments. The rise is not made 'towards' the continuous note, nor 'away from' it.

What we were in effect trying to do in these last few experiments was to produce in the qualitative field experimental conditions more or less similar to those which gave rise to the impression of launching. Another alternative, however, is possible, namely to start from the theory which underlies this impression, and in a final experiment this is what we did.

The essential point in mechanical causality, as we have seen, is ampliation of the movement, i.e. the extension on to one object of a movement which belongs and continues to belong to a different object. Could not something similar be devised in the case of a qualitative property? On the face of it this seems by no means impossible. Do we not regularly see light being transferred from its source, e.g. a projector, on to some other object in the form of a visible beam? Is there not something here which is similar to ampliation?

The question is indeed a highly debatable one in view of what we know about perception of shadows, reflections, and so on. In spite of this, however, we tried to proceed empirically and set up an experiment in which the case that we had in mind would be reproduced as closely as possible.

Exp. 90. For this experiment we made use of the fact that gamma movements can in certain circumstances be polarised.

The experiment consisted in producing in turn, on a faintly illuminated screen at an interval of 6 or 7 centisec., (i) a circle of light 18 mm. in diameter, and (ii) a long isosceles triangle of light 100 mm. high, having a base of 20 mm. The apex of the triangle touched the

periphery of the circle and pointed towards the centre. In these conditions the first thing which appears is the circle, and we see it expand (perform a gamma movement). Next the triangle appears, starting at the apex and growing towards the base (thus giving rise to a gamma movement polarised by the circle and appearing to come from it). The triangle thus gives the impression of being a spreading beam of light emerging or starting from the circle. An object was fixed to the screen or drawn on it; its position on the screen was such that part of the image of the triangle was superimposed on it and lit it up.

Four experienced subjects took part in this experiment, and the results were once again completely negative. The beam of light does not give the impression of *belonging* to the circle but of coming out of it like water from a tap. Moreover there is sometimes the impression that the circle and the beam of light form a single whole which comes into existence gradually. When the object lights up, the lighting-up certainly does not appear as a change in the object; it seems rather to be something apart from the object, which passes over it or is superimposed on it. There is thus no question of a change *executed by* the passive object, as occurs in the case of mechanical causality.

Instead of projecting the beam of light on to one particular place, as was done in this experiment, another possibility is to make a change in the general illumination. If this is done, there is no major difference in the results. Any change that occurs in the brightness or colour of the objects does not seem to be *produced by* the change in illumination. There is merely concomitance.[5] Incidentally, when such changes occur in the conditions of everyday life, they are very frequently accompanied by apparent movements (gamma movements, stroboscopic movements and displacements of shadow), and this sometimes gives a semblance of causal impression; but in more rigorous conditions there is no trace of it.

Our general conclusion, then, is negative. In spite of a large number of attempts, we have not been able to discover any case of causality

[5] The distinction between the light shed on the objects and their own colour is a phenomenon of double representation. In this respect the situation is comparable with that found in the Transport Effect, as it occurs e.g. in exp. 51 (p. 152). A change in illumination must necessarily have an effect similar to that produced by an acceleration of the movement of the transporting object. There, too, there was no causal impression, merely change in the speed of the movement of the transporting object occurring simultaneously with change in speed of the 'displacement' of the transported object. The apparent alteration in colour which accompanies a change in illumination would then be comparable to a change in the amplitude of the oscillations of the transported object (exp. 51), coinciding with an acceleration of the forward movement.

among changes which were purely qualitative or were changes of intensity.

An attempt was made earlier (Chapter XIV) to show that the 'productive' character of causality could be understood within the framework of the theory of ampliation, and it seemed most unlikely that it could exist in any other conditions. Now it is obvious that in the majority of cases which we have considered, particularly in the impact-noise example and that of the rise of notes on a scale, to apply the concept of ampliation makes no sense. Moreover ampliation implies double representation, and can be expected only in spheres where double representation is possible. The case where we perceive change of colour and change of illumination seems at first sight favourable from this point of view, but we found that there was no ampliation in these cases either. *The direct experience of causality is thus the prerogative of mechanical causality*. The reason for this no doubt lies in the remarkable properties of phenomenal movement which have frequently been mentioned throughout the whole of the first part of this book.

If we reflect on this conclusion, we are bound to call to mind the fact that the first physical theory which developed in the history of modern thought was the mechanistic theory of Descartes. Here, of course, the notion of 'impact' plays a crucial part in supplying causal explanations, and one cannot help suspecting that this is not a mere coincidence. It was surely the perceptual apparentness of mechanical causality (and mechanical causality only) which constituted the psychological basis of the Cartesian approach in general.

SUMMARY NO. 4

Résumé of Chapters XV and XVI

The purpose of the experiments described in the last two chapters was to test whether it was possible to obtain a causal impression in the following two sets of conditions: (*a*) when a qualitative change in one object and the movement of another contiguous object occur in quick succession, and (*b*) when a qualitative change in one object is immediately followed by a qualitative change in a nearby object.

The results obtained show that there can be a causal impression in case (*a*) provided the qualitative change involved is the appearance or disappearance of an object (and possibly also a change in colour). This, however, seems to be due to the fact that the changes are accompanied by apparent movements (particularly gamma movements). Indeed the causal impression appears only in cases where apparent and 'real' movements combine so as to reproduce the same conditions of direction, etc., as are required when both movements are 'real'. This occurs when there is an impact followed by the disappearance of the object struck, or when one object suddenly appears beside another and the first object moves off.

To link together purely qualitative events we have made use of instantaneous or gradual changes in colour, the sudden illumination of an object by a beam of light emanating from another object, variations in pitch in a series of notes, the production of a noise at the same time as a visual event, and so on. These attempts met with no success, and indeed it is difficult to see how the concept of ampliation, which has been found to be of fundamental importance for the understanding of mechanical causality, could apply in the qualitative field.

We are therefore forced to conclude, in the absence of any indication to the contrary, that the causal impression is not found with purely qualitative changes, and in fact arises only when there are combinations of movements or of changes in shape.

It should be mentioned, however, that in cases where the occurrence of a noise coincided with a visual experience of *activity*, as in the case of a simple impact, or where there is a visual experience of *causality* such as the Launching Effect, the observers could be induced to say that the

noise was 'produced' by the impact. But this occurred only when it was possible by special means to ensure a close link between the auditory and visual events, the result of which was to make the former a simple property of the latter. It seems therefore that the application of the causal relation to the noise in these experiments was the result, in the last analysis, of integration of the auditory impression in *a visual experience of mechanical causality* (or at least in an experience of activity which spontaneously assumes a causal 'significance'), a phenomenon which we met in Chapter XII and which will be discussed again in Chapter XVII.

THE ORIGIN OF THE IDEA OF CAUSALITY

CHAPTER XVII

Critical Reflections on Different Theories

It would clearly be very interesting if experiments such as those described in this book could be tried out on children of different ages. Unfortunately plans for such research have not yet advanced beyond the project stage. I think, however, that the results which we already possess throw some light on the question of how the idea of causality originates, and enable us to take a definite standpoint vis-à-vis certain psychological theories on the subject which have been put forward. This issue forms the subject-matter of the present chapter. Philosophical theories of causality are clearly outside the scope of this book and will not be considered here.

1. HUME'S THEORY

It has been generally accepted since the time of Hume that the successive events given to us in experience are independent and isolated from each other, and that we have no 'experience' of a causal link between them. As has already been emphasised, the results of our research indicate that this view is mistaken.[1]

Such a claim may seem astonishing. If the perception of causality is the common occurrence which we say it is, how could this have been overlooked by anyone of Hume's penetrating intellect? And how has the same mistake been repeated by followers of Hume during the course of two centuries? This is undoubtedly a problem.

It seems certain that Hume did not realise that there was such a thing as the *causal impression*. His writings are so definite on this point that the matter does not admit of any doubt.[2] Now this is not as sur-

[1] It should be remembered that we are concerned here only with the popular idea of causality, or in other words with the 'production' of one event by another. We are in no way concerned with the scientific or philosophical idea, nor *a fortiori* with the 'principle of causality'.

[2] 'Motion in one body is regarded upon impulse as the cause of motion in another. When we consider these objects with the utmost attention, we find only that one body approaches the other; and that the motion of it precedes that of the other, but without any sensible interval. 'Tis vain to rack ourselves with *farther* thought and reflection on this subject. We can go no *farther* in consider-

prising as we might think at first sight, since, as we know, the adoption by the observer of an analytical attitude can prevent the formation of a causal impression and bring about the complete segregation of the movements. In the case of the Launching Effect this occurs very readily if the objective conditions for integration are not very favourable, e.g. if the movements are not in the same direction or if there is no hierarchy of speeds. All Hume's psychological work shows that he did in fact adopt this analytical attitude and that it was his normal one, as we mentioned earlier (see p. 8). In addition we must not forget that Hume, in making his assertions, was dependent on incidental observations, or else on rudimentary experiments which lacked precision and in particular which had none of the operational safeguards that are indispensable for psychological research.

To avoid a possible misunderstanding a further point should be made. If Hume had been able to carry out experiments such as ours, there is no doubt that he would have been led to revise his views on the psychological origin of the popular idea of causality. He would probably have appealed in his explanation to the 'causal impression' rather than to habit and expectation. This causal impression, however, would have been for him, as for Malebranche, nothing but an illusion of the senses, as is shown by his views with regard to the feeling of effort.[3] Moreover it is probable that his philosophical position would not have been affected in the least.

There remains, however, a further question. If we take it as established – as I think we may – that the basic causal impression occurs only when certain mechanical movements are combined, and does not occur in cases of pure qualitative causality, then the problem raised by Hume arises in a new way; for why in that case do people regularly apply the idea of causality to qualitative changes?

ing this particular instance.' HUME, *A Treatise of Human Nature*, part III, section ii.

'When we look about us towards external objects, and consider the operation of causes . . . we only find, that the one does actually, in fact, follow the other. The impulse of one billiard-ball is attended with motion in the second. This is the whole that appears in the *outward* senses. The mind feels no sentiment or inward impression from this succession of objects.' HUME, *An Enquiry Concerning Human Understanding*, section VII, part i.

See also the passage quoted on p. 7.

[3] See note 7, p. 7, and also p. 9.

Now there are many cases where a causal interpretation must be the result of an elaboration, by means of reflection, on the data of experience. This is true, for instance, of the relation between the sowing of a field and the later appearance of the crop, or the heating of water and its starting to boil; and in the sphere of mechanics it is true as an explanation of occurrences such as the negative cases mentioned earlier – the obstruction of a moving object by an obstacle, braking, attraction, rebounding, and so on. Since causality is not 'given' in these cases, the idea of it cannot be derived directly from the 'experiences' in question. Thus the claim that causality is intervening must rest on an inference, an inference which itself presupposes the existence of an original idea of cause.[4]

It seems, however, that when we apply the idea of causality to qualitative events we often do so in a much more immediate way, as is apparently indicated by the results of our impact-noise experiments.[5] These experiments showed that the majority of observers felt inclined to say that the impact produced the noise, so long as the noise occurred under certain conditions; and there is no reason why the same should not hold in a very large number of other cases. It is therefore not unreasonable to put forward the hypothesis that, when a qualitative event occurs *in certain definite circumstances*, a causal interpretation is urgently called for.

What are these circumstances? The impact-noise example suggests, as we have seen, that the determining factor is the phenomenal integration of the qualitative event in an experience of genuine causality (e.g. the Launching Effect), or possibly in an experience of acitivity.[6] The qualitative event then becomes taken up in the total impression of causality or activity.

For this experience, then, two different requirements must be satisfied. The first is that there should be an impression of causality or mechanical activity; the second is that the qualitative event should be integrated in this impression.

Now it seems that these conditions are in fact satisfied in a very large number of cases in everyday life. Here are some examples: the

sound produced when someone strikes the key of a piano, blows a wind-instrument, or draws a violin bow across the strings, the sound made by an electric bell when someone presses the button, the ticking of a clock when someone rewinds it, and the starting of a car engine when someone presses the starter. In the same group we may also include vocalisation; in speech the sounds are linked with very complex mechanical activities of the tongue, lips, etc., occurring in the conditions which are necessary for the production of a causal impression. This is true in particular of the movement of the lips; one lip is continually pushing or pressing against the other, and these are standard cases of tactile-kinaesthetic 'propulsion'.

In the examples quoted, and in the further examples which follow, it is not necessarily the observer who is the causal agent. He may simply have a visual perception of another person, or even a machine, engaging in some causal activity.

Similar cases are to be found in the visual sphere, e.g. the lighting of an electric lamp when someone presses down the switch, the breaking of a clay pipe as seen at the shooting range at a fair, a bicycle visually perceived as making a forward movement in relation to downward pressure on the pedals, or the movement of the needle on a dial when someone presses a button.

In the tactile sphere we may mention the impression of coolness when a person uses a fan, and the feeling of pain which follows when a person is struck, pinched, or pricked.

Indeed we need only look around us for innumerable such examples to come to hand.

Now it is clear that we apply the idea of causality to these cases quite spontaneously, and apparently without any reflection or reasoning. Obviously, therefore, they must possess certain features which provide the justification for this.

It may perhaps seem surprising that the integration of a different kind of event in the causal experience proper occurs with such frequency in ordinary life, when we had so much difficulty in bringing it about in our impact-noise experiments. We must not, however, lose sight of the fact that the complex circumstances of daily life are far more favourable to integration than are the artificial and simplified conditions of the laboratory.

The crucial factor of similarity, whose importance we recognised in the case of the impact-noise experiments (where what was involved

was similarity of temporal properties), must constantly intervene in the form of 'common fate'.[7]

In addition subjective attitude must also play a considerable part. We were forced to have recourse to it in our impact-noise experiments, when by structuring the questions we induced in our subjects a state of expectation. Now this factor operates regularly in ordinary life. The motor activities involved are often voluntary; and the result obtained is therefore something which we deliberately aim at. Thus in the example of the clay-pipe, mentioned just now, the breaking of the pipe is clearly linked with the activity of pressing the trigger of the rifle. We have seen how effective is an expectation of this sort in setting up phenomenal links. Moreover the result itself is frequently an event which produces a strong feeling of satisfaction. This is clear, for example, if we consider how much children enjoy switching on a light, blowing a whistle, striking a note on the piano, etc. Thus the link is strengthened not only by expectation but also by the 'law of effect'.

If this is so, however, and if our hypothesis is correct, the conclusion follows that experiences of mechanical causality are far more numerous than they appear to be at first sight. Countless numbers of events are permeated with causality; it is something which occurs in practically every situation.

It is possible to think of still further ways in which the same principles can be applied. If it is true that the close link between a non-causal event and a distinct event which itself possesses a character of activity or causality results in the first event sharing the causal character of the second, does not this explain why certain changes which seem to take place in the appearance of things are felt by us to be *subjective* in origin?[8] Where changes of this sort occur in close relationship with a subjective activity (such as 'direction of attention', for example), they become

[7] My colleague Professor Nuttin has very relevantly drawn my attention to the good example of dissociation which occurs in the case of ventriloquism. Here, as we know, the normal movements of articulation appear to be missing, and a dissociation thus arises between the sound of the voice and the person speaking. A familiar example of a similar segregation occurs in the case of 'doubling' in sound-films when there is no connexion between the words and the actor's lip-movements. In contrast, the fact that deaf people find it comparatively easy to 'lip-read' the words of others brings out effectively the importance of the similarities that exist between the arrangement in time of the flow of speech and the arrangement in time of the movements of articulation.

[8] This sometimes occurs, for instance, in experiments involving reversal of perspective or inversion of figure and ground, when the observer has the impression that he himself is bringing about the changes which he sees.

enveloped in this activity and give the appearance of being a manifestation of it. In the absence of this integration, however, the alterations would have an objective character even when their origin was really subjective.

Another application, also of extreme importance, concerns the relationship between motivation and causality. We all know how much confusion there is on this subject, and how frequently people fail to make a distinction between 'cause' and 'purpose'. We constantly find that children and even adults are satisfied with 'explanations' in terms of purpose, and attribute to them a causal significance in the sense of 'efficient' causality. It is clear, too, that everyone considers desire, aversion, fear, and anger as possible 'causes' of his actions; and it may well be that we have here situations which once again are analogous to those of 'qualitative causality'.

The qualitative event – the emotional or motivated state – often precedes a physical action, e.g. of pulling something towards ourselves, taking it up, pushing it away, and so on, and is closely linked with the corresponding causal *impression*. Here, surely, is to be found the basic reason why people attribute a causal rôle to emotions or sentiments, some of which perhaps possess in themselves a character of immanent activity but not of causality in the strict sense.

All this is no more than hypothesis, and requires confirmation. Now in some cases, e.g. that of simple qualitative causality, it would not be difficult to proceed to verify these hypotheses experimentally. This would enable us to state them in precise terms, and perhaps also to understand a somewhat remarkable fact, namely that there is often a shift from the impression of causal motor activity to the immediate physical effect of this activity. Thus in piano playing, for example, when a note is sounded, the occurrence of the sound is attributed causally to the depression of the key, and not to the motor activity which produces the depression, even though, on our hypothesis, it is precisely from this motor activity as such that the causal character comes. Should we see in this the result of reflection and reasoning, or is it the effect of certain factors of organisation operating in a more direct way? It is difficult to say, but many indications seem to suggest that the second supposition is the correct one.

Before this discussion of Hume's views is brought to a close, a few words should perhaps be said as to what bearing our research has on the characters of necessity and universality, which are normally attached to

the notion of 'cause'. As for universality, in so far as this is not bound up with necessity, it seems that the same holds for the causal impression as for any other phenomenal link; and we shall therefore spend no more time on the matter here. Our research, however, does, I think, enable us to make a number of suggestions on the subject of necessity, or at least of 'apparent necessity'.

It should be remembered, first of all, that the psychologists of the Gestalt school (Wertheimer, Köhler, Duncker, and others) have emphasised that, when certain processes are in course of taking place, they 'require' to be continued in a definite way. If they are halted, or if their direction suddenly changes, this produces a feeling of deception, surprise, or displeasure. This can be seen in particular in the case of rhythmic series, melodies, the shape of the path traversed by an object, and even in the case of a simple, fairly rapid movement when the object in motion suddenly ceases to move. Conversely, when the process is continued without interruption, the result seems satisfying or normal; it seems to develop 'according to plan'. The same no doubt also applies to the experience of causality; and this is probably one of the characters which differentiates it in such a clear way from a simple impact in which the moving object comes to a halt. It is difficult, however, to see here a genuine necessity; it is rather an 'invitation', and an invitation is neither an obligation nor a decree of fate.

Very long ago Claparède pointed out, in his examination of Hume's theory of causality, that, contrary to what Hume supposed, the repetition of experiences is by no means indispensable for establishing the necessity of a link.[9] Thirty years later, taking up this idea and developing it, Claparède wrote:

'My claim is that the feeling of necessity appears at the first encounter of the associated elements. If the child is burned at the stove or is clawed by the cat, he will run away from both, without

waiting for repeated experiences to convince him that the stove burns and the cat claws. All that experience does is to destroy this relation of implication when it is shown not to be legitimate. Implication is thus a primary tendency.[10]

'The very young child as yet knows only one cat, that at home, which is black. . . . How, until experience has taught him the contrary, could he imagine that the colour black is not a necessary attribute of cats, as it is of crows, coal, or coffee?' (p. 103).

'If we were not disposed, in meeting an object for the first time, to regard its qualities as necessary attributes, how should we know how to behave when we had to deal with it the second time?' (p. 104).

'The necessity of a connexion thus tends to appear at the very start' (p. 105).

The view expressed in these passages cannot, I agree, be accepted without reservations, since it is difficult to escape the impression that Claparède has sometimes passed outside the limits of psychology and entered into the sphere of logic, particularly when he speaks of implication and the relationship between object and attribute.

In spite of this, it was interesting to examine to what extent our own research gave grounds for accepting or rejecting the essentials of his thesis. In this connexion there arises a very remarkable point.

If we ask ourselves for the first time whether our experiments on launching and entraining present a character of 'necessity', it is very difficult to give an answer. Indeed those to whom the question is put usually answer in the negative; they say that they see no *necessity* that object A should drive away or carry off object B, and that it could quite well stop after reaching B. There is no more necessity here than there is that such and such a book should be put in front of me on the table or that the light should be switched on.

Such a reply indicates two things. In the first place it suggests that the question has been badly put, or, rather, not properly understood,

[10] See E. CLAPARÈDE, *La genèse de l'hypothèse*, Kundig, Geneva, 1934, p. 103. He defines the notion of implication, to which he attaches considerable importance, in the following way: 'This implication consists in the fact that if a phenomenon is thought of as given, *then* another phenomenon will necessarily also be thought of as given. Thus in implication a certain object or event is thought of as being necessarily contained in another or necessarily produced by another. Thus quality is thought of as contained in objects, cause in effect, effect in cause, consequence in motive, and so on. To say that "A implies B" is to say that A carries along with it the presence of B.' Later he says, 'Subjectively we feel implication as an internal *constraint*' (pp. 101 and 102).

since the observers are clearly considering only the total action as such, i.e. the whole operation of launching or entraining. Indeed this is quite understandable, since the most striking character of the experiment is precisely that we are present at a single operation of the whole, brought about, it is true, by the co-operation of two actors, but with one of them, A, playing the important part, while the other, B, is only a supernumerary (see pp. 72, 141 and 149). Secondly, the denial of necessity brings out the apparent spontaneity of the *action* which takes place here – an action which at the start shows no sign of necessarily being fated to happen.

If, however, we ask the question from the point of view of what is happening at the actual heart of the operation which we see occurring, and if we ask about the appearance of the events comprising this operation, it is quite a different matter. The experiments can be described, as we have seen, by saying that the blow dealt by object A *drives away* or *carries off* object B; it is A which does everything, and B which is completely inert. This amounts to saying that A *exercises a constraint* on B. The change of position of B is certainly not 'free'; it is something 'forced' or 'imposed' by A. In this sense, then, there is clearly a 'necessity' for the change of position of B – a necessity which arises as a result of the blow which it receives from A. This character is clearly apparent when we compare the launching experiments with cases in which the movement of B is made spontaneously, e.g. as a result of introducing a sufficiently long interval at the point of impact, or even with cases where B's movement is autonomous, as in the Triggering Effect.

We are not concerned here, of course, with necessity in the logical sense, for it would be perfectly possible to suppose without absurdity, even if it had never in fact been observed to happen, that B could set off on its own accord after being struck by A. It is rather a 'necessity' of fact, a purely phenomenal constraint, one which is not just a 'feeling of necessity' but one which is inherent in the event itself and is a character belonging to it.

This character of 'necessity', then, can occur in a single experience, independently of any repetition; and this point fully confirms the somewhat bold statements made by Claparède on the matter.

It goes without saying that similar constraint is also found in the Entraining Effect, but here there is a further complication. It is clear that in this case *object B must necessarily be displaced for object A to be able to advance*; in other words the departure of B is an indispensable condition for the continuation of A's movement, since at each moment

of its advance A occupies the place which B has just left. This necessity is a logical one, provided we accept the postulate of the impenetrability of matter; and there is no doubt that perceived *objects* possess the character of impenetrability from the phenomenal point of view.[11]

The observer, it is true, does not think of all this at the moment when he sees one object push another away, nor does he make explicit to himself that the Entraining Effect involves the successive occupying by the two objects of the same positions in space. In spite of this, however, there is in the pushing something intrinsically necessary, which imposes on it a character of coercion which is even more marked than that occurring in the case of the Launching Effect. Undoubtedly we have here an example of that strange 'intuitive logic' which plays so large a part in the solution of 'visual' problems and in a general way in the 'pre-verbal' understanding of which Janet speaks.[12]

It should be pointed out, however, that the necessity in this case does not indicate a relationship parallel to that expressed by the laws of physics in respect of the impact of bodies, for it is concerned only with the possibility of movement on the part of the motor object, and in no way with the conditions determining the displacement of the object moved. In spite of this, and no doubt because of its lack of explicitness, the necessity in question gives to this displacement a special character of inevitability.[13]

[11] There is a considerable amount of evidence, some of it very curious, which supports this view. When we create experimental conditions which *a priori* might be thought capable of giving rise to a penetration of matter, the most common result is that a three-dimensional structure is established (one object slides behind or in front of the other), with the front one sometimes seeming transparent. In other cases the outer edge of one object acts as a real barrier against which the 'matter' of the other object accumulates, instead of penetrating the obstructing body as it should do. This is a fresh example of microkinesis. It is only in very special conditions that we can perhaps (?) obtain a phenomenal duplication such that one piece of 'matter' can seem to belong to two different objects at the same time.

[12] See note 3, p. 5.

[13] While on the subject of necessity we may recall what was said earlier in connexion with causality (see p. 228). Since the character of 'necessity' belongs to the displacement of an object whenever this displacement occurs during the course of certain combinations of movements, and since these combinations normally occur only when bodies come into physical contact, there is clearly a fairly widespread parallelism between the character of 'necessity' and the operation of the mechanical laws relating to impact. This is interesting, since it follows that the character of 'necessity' attaches itself to certain sequences of events before it is possible for the laws governing these events to be known.

In general, then, the causal impression bears a character of necessity or constraint; and it is probable that this character is not limited to purely mechanical actions, but extends also to the qualitative events which are linked up with them (thus constituting instances of qualitative causality) (see p. 247). The case, cited earlier, of the child being clawed by the cat is perhaps an example of this. Hence we may accept Claparède's suggestion that the enlargement of our experience does not have as its primary result the establishment of necessity by repetition of the same subject-matter; on the contrary its result is to show that there must be contingency because of the variability of the observed data. Thus a single experience of causality could lead the child to believe that there is a necessary link between his own act of pushing and the displacement of the object which his hand is touching, but he will soon notice that, even though he can push back his blankets, a similar push against the side of his cot does not move the cot away. After many later trials, he will then gradually be able to differentiate the conditions in which the push is followed by the 'necessary' displacement of an object and those in which this does not occur. From this time onwards necessity will be attached in a selective way to certain conditions; thus the child will realise, for instance, that the character of necessity applies only when he is confronted with objects apparently segregated from their surroundings, such as a ball, a rattle, etc.

In short, the chief result of the repetition, or more strictly the accumulation, of experiences which arise in more or less similar conditions is that we can make precise the conditions in which events occur having the *appearance* of being determined by their antecedents.

One final point, on the theoretical side, requires to be stressed. All that has been said confirms once again, in conformity with the whole trend of our results, that the Entraining Effect and its immediate derivatives, the different types of propulsion, are not only the most frequent forms of causal impression found in ordinary life; they are also the most perfect or complete ones from the point of view of structural organisation, and those in which the character of necessity is the most marked. The Entraining Effect is thus the *basic form* of the causal impression, while the Launching Effect is only secondary in relation to it. This conclusion is completely understandable if we refer back to what was said in Chapters VIII, IX, and XIV. Taking into account all the data mentioned in these chapters, we are finally led to regard the Launching Effect as a

modified or inferior version of the Entraining Effect, differing from it only in that it involves (i) a stopping of the motor object at the moment when the two objects come into contact, and (ii) a dissociation between the 'movement' of the motor object and its position in space, as has been explained on p. 135 and following.

2. MAINE DE BIRAN'S THEORY

The problem of the origin of the idea of causality presents greater difficulty if we raise it in connexion with 'internal' experience. Research in this case is very much more difficult, and cannot be controlled by systematic variation of the experimental conditions.

Since our research has established the existence of causal impressions in the realm of external experience, it follows that internal experience is not the only possible source of the idea of causality. We can press home the criticism further, however, and ask ourselves to what extent this internal experience is even capable of giving rise to the idea of causality. If the answer is that it can, we still need to settle a question of fact, viz. whether the idea of causality develops in the child from internal experience or from external.

There is no doubt, as has been shown earlier, that our own motor activity, and especially our voluntary motor activity, can give a causal impression when the consequence of it is to bring about a mechanical change in an external object or in a part of the body distinct from that which initiates the change.[14] This is in no way a feature peculiar to animal movement, but must be regarded as one case, among others, in which a certain kind of structural organisation is set up.

It was not to phenomena of this kind, however, that supporters of the 'internal experience' theory appealed; indeed such a possibility seemed to them actually excluded in view of Hume's theory, which in respect of external experience they accepted as correct. According to Maine de Biran, the classic authority on the matter, it was the 'feeling of effort' characteristic of voluntary movement which was the 'primary fact' and constituted the Type-experience of causality.

Now the feeling of effort in no way corresponds to the production of an external effect, and Biran expressly criticises Engel, one of his opponents, for saying that the effort to overcome an external resistance plays a part in giving us the idea of force.[15] Nor is it the will as such, nor the will considered in relation to motivation. Again, Biran's 'effort' implies

[14] See p. 203. [15] See G. MADINIER, op. cit., pp. 122 and 127.

nothing arduous; it is only 'the initiating of a movement experienced in the passivity which this initiation encounters'. The 'passivity' to which he is referring lies in the 'mass of resistance' formed by one's body, in the resistance of the bodily organs which occurs in the form of muscular sensation.[16]

Biran's view is clearly stated in the following passage:

> 'Effort, willed and immediately perceived both in our determining of it and in the active movement itself (a phenomenon of consciousness perceived as an effort which necessarily displays the cause producing it) is a single fact composed of two elements, a single relation with two terms, neither of which can be separated from the other without changing its nature, or without departing from the concrete to the abstract, from the relative to the absolute. Will, considered in the soul apart from its effect, resolves into the idea of absolute force, an idea of quite a different kind, and one which cannot be primary. Movement considered objectively in the muscle organs, in isolation from the will which makes it actual or becomes actual in it, is a physiological fact or a sensation like any other, and there is nothing active in it. In speaking of the *link* – I do not say between two facts but between two necessary elements of the same fact – I am simply stating the primary fact of consciousness, no more than that.'[17]

It is not my intention here to go afresh through the different stages in Biran's argument; other writers have done this very effectively already.[18] My purpose is simply to indicate the contribution which our own research can make in examining this question.

In this connexion our observations on auto-locomotion are, I think, of some interest.

The 'primary fact' corresponds to what we called earlier voluntary movement 'in the air', movement of the body in isolation. In discussing such movements we said that they possessed a very special feature, that of *immanence*, corresponding to the joint operation of tactile-kinaesthetic microkinesis and the change in shape (or movement) of a limb or the whole body. Now immanence is not only a feature of voluntary move-

[16] See p. 203.

[17] Biran is here replying to arguments against the immediate apperception of a causal link between will in its basic form and movement. See *Oeuvres Choisies*, p. 236, and also the passages quoted on p. 11 of this book.

[18] See in particular L. BRUNSCHVICG, op. cit.

ment, but it also occurs in reflex activity. The difference between the two consists in the fact that voluntary movement involves the effacement of the body-object in such a way that there remains from the phenomenal point of view only a 'pure' immanent mechanical activity, i.e. one in which there is no longer an object performing the movement; and it is this activity which is attributed to the 'I' which takes the place of the limb or the body.[19]

There is no doubt that Biran fully realised that this character of immanence was present in voluntary motor activity; this is clear from all the passages in which he tries to make precise the nature of the 'primary fact', e.g. the following:

> 'The feeling of "self" is not one that comes to man from outside; it is the immediate product of a force which is his own and innate (*vis insita*), whose essential characteristic is that it is determined by itself; and in so much as it is determined in this way, it perceives itself immediately, both in its free determining and in what it produces, in the cause and in the effect, which being indivisibly linked together form the fundamental relation or the primary fact of consciousness.'[20]
>
> 'The cause feels itself or perceives itself in the effect, which is itself consciously felt or perceived only in the muscular sensation which it produces.'[21]
>
> 'There are not two facts, two specifically different modes, connected accidentally, but a single fact – one and the same active mode, relative by its nature in such a way that one cannot isolate one of its two constitutive elements without annihilating or destroying it.'[22]

Biran insists throughout on the unity of the 'primary fact', on the impossibility of isolating it without making it lose its special character, and on the immanence of the cause in the effect; and although the expressions which he uses have a much more metaphysical flavour than ours, I do not think there can be any doubt that they relate to one and the same phenomenal aspect of motor activity.

Now it is at this point in particular that our own experiments seem

[19] See pp. 201 seq.; the whole of Chapters XII and XIII are relevant to the discussion which follows.

[20] M. F. MAINE DE BIRAN, *Oeuvres Choisies*, p. 151.

[21] Quoted from L. BRUNSCHVICG, op. cit., p. 29.

[22] Quoted from G. MADINIER, op. cit. See also the passages quoted on p. 11 of this book.

to me to be of interest as far as the present discussion is concerned. The phenomenal character of immanence is not, strictly speaking, an 'experience' of causality. That at least is the conclusion which seems to emerge from expts. 65, 66, and 67 (the 'caterpillar' and 'frog' experiments; see pp. 184 seq.). The distinctive impression of live movement has turned out to be qualitatively different from the causal impression obtained from experiments on launching and entraining (including propulsion). It may perhaps be thought surprising that we are making use of an argument from the visual perception of animal movement to criticise Biran's theory, but we must not forget that these perceptions are very closely related to the 'primary fact'; the caterpillar moves just as we move when we do so voluntarily, and just as the substance of the caterpillar appears to be the origin of the movement which animates it,[23] so it is the 'I' which is thought of as the source of voluntary movement. If it is objected that in the case of voluntary action the object performing the movement disappears, this reinforces our conclusion rather than otherwise, since the presence of an object performing the movement seems favourable to the causal impression.[24]

If we take all this into account, we are right, I think, in being very sceptical as to the possibility of deriving the idea of cause from the 'primary fact'. It seems certain that it is not actually 'given' there, as it is in the cases of launching and entraining, and the vague character of 'productivity' which attends immanent motor activity is very much less clearly defined.[25]

It may perhaps be argued, however, that immanence implies causality, and that the impression of immanence must take on for human beings a causal significance. To such an extent is that so, it would be said, that we cannot adequately describe the 'given' except by saying that the animal itself *produces* the movement which it performs. Only by expressions of this kind is it possible to put into words the features which differentiate the movement of an animal from that of an inert object, e.g. a dead leaf which we see fall from a tree or an object which we see launched or entrained by another object. Does it not follow that the 'given' is automatically 'understood' as being causally determined?

This way of looking at things is, of course, very different from that of Biran, since causality is no longer being regarded as a datum of experience. It comes nearer to Kant's view, according to which causality

[23] See p. 198. [24] See Chapters III and IV. [25] See pp. 195 and 199.

must be considered as an *a priori* form of the understanding which somehow 'informs' the given.[28]

As we have just seen, it cannot be denied that to put into words the impression of immanence we find ourselves spontaneously using expressions having a causal significance, and that these expressions are immediately accepted as adequate by the observers to whom they are proposed. This occurs, so it seems, without any systematic analysis being made, i.e. without the observer being expressly aware of the presence of different movements (microkinesis and change in shape, and dilatation-contraction and forward movement), and without his being aware of the necessary link between them in virtue of which one must evoke the other. If all this were made explicit, we should clearly arrive by reflection at the establishment of a causal link. This, however, presupposes an intellectual elaboration which is certainly not performed consciously, since observers are generally rather surprised when their attention is drawn to the existence of a microkinesis and the distinction between it and the change in shape, or to the difference between the impression of dilatation and that of forward movement and to the relations which link them. They are likely therefore to be still more surprised when someone tells them of the existence of a distinction and other such relations between the kinaesthetic microkinesis and the change in shape of one's body during the course of the movements which it performs.

Expressions having a causal significance, then, are forced on us at the start, even before their justification is made explicit.

Clearly this is a matter which raises difficulties. Nor is the problem limited to the present case; other examples of it are to be found throughout the psychology of thought and reasoning, which is the place where the study of such problems therefore belongs.

As far as the present case is concerned, however, the situation is perhaps not as puzzling as it might seem. The position, one might say, is this: (i) There are some cases, viz. launching and entraining, in which

[28] No systematic exposition of Kant's account of causality has been given in this book, since it belongs essentially to the field of philosophy. His position is similar from the phenomenal point of view to that of Hume, at least in so far as he claims that causality can neither be given in external experience nor felt in the sphere of internal experience; apart from this he is in effect simply putting forward the psychological theory – which all our observations have shown to be false – of a simple causal 'significance' or an 'interpretation' superimposed on the given.

a causal impression arises, clear, genuine, and unmistakable, and the idea of cause can be derived from it by simple abstraction in just the same way as the idea of shape or movement can be derived from the perception of shape or movement. (ii) There are other cases, viz. immanent mechanical activity, which give a vague impression of 'productivity', and the corresponding idea can similarly be derived from them by abstraction. To avoid all verbal misunderstanding, however, it needs to be emphasised that the 'productivity' in these cases is very different from the causal impression; and the corresponding concept cannot therefore be identified with that of causality.

This being so, it is quite logical to allow that the causal impression in the strict sense forms the basis on which the clearly defined idea of cause is founded, and that, once acquired, this idea can be applied without further consideration to the case of immanent activity, as a result of the qualitative likeness between the phenomena.[27] This view does not necessarily have any significance as regards origins, and it is not impossible that the idea of vague productivity should arise in the young child before that of causality; but even if this were so, the latter would still be the genuine causal impression which gives its full meaning to the everyday idea of cause.

In short, it seems certain that Maine de Biran's 'primary fact' cannot be regarded as the source of the idea of cause in the strict sense. Biran's mistake, as we said in the Introduction, was to confuse immanent activity and causality, and to suppose that the *idea* of causality which we apply to the *fact* of immanent motor activity is derived from this fact. He was led to adopt this view because immanent activity, on account of its qualitative relationship with causality, invites us to make a causal interpretation, to invest what we see with a causal significance; and, as Brunschvicg aptly puts it:

> 'We see here the lack of a methodological technique capable . . . of making a distinction between what is given in the facts and what is implied in them, between what empiricism discovers and what rationalism infers.'[28]

Biran's theory is vulnerable in another respect. Even supposing that voluntary movements did constitute a Type-experience of causality,

[27] The same is no doubt true of the application of the idea of causality to other cases where there is an impression of (non-immanent) activity. See p. 199.

[28] L. BRUNSCHVICG, op. cit., p. 46.

how and why should the idea derived from it be applied to the data of external experience? The solution put forward by Maine de Biran, as we saw in the Introduction, was to allow the existence of a transference achieved by means of an 'initial induction'.[29] Now our results do not appear to be compatible with such a view. If it were correct, it would seem that events in nature can at the very most take on a causal 'significance' which is simply attached to or superimposed on the given, and that the phenomenal character of the given is not altered at all.

There is another theory which is perhaps not open to this objection, the well-known theory of Einfühlung (empathy), in the sense given to this word by Lipps in his writings on aesthetics.[30] According to this view a sort of fusion takes place, through assimilation, between internal experience and the data of external experience, a projection, e.g. of our own feelings on to others or even on to inanimate objects perceived

[29] This is how Biran puts the matter in his *Reply to Stapfer* (*Oeuvres Choisies*, op. cit.):

'If the necessity, the invariability, and the unity of the primary personal cause are considered in this way, all the derivatives of this primary fact will necessarily share in the same character. For example . . . no passive modifications can begin without its being immediately attributed to a cause conceived after the manner of the self. This initial induction which carries the causality of the self over to the not-self has no connexion with the judgement of similarity founded on the perception of resemblances in external experience. Thus it is with reluctance and for want of a better word that I use in this new psychological sense the word 'induction', which has a quite different meaning in logic and in physics. However that may be, the certainty that an external movement or a passive modification in our sensibility – any sort of chance event which we do not produce by an act of will – could not have begun without a cause – this certainty, I say, is as infallible and necessary as that of our own personal causality from which it is derived; it is the antithesis proved or justified by the thesis, passion manifested by its contrast with action' (p. 248).

To Biran this is not a logical necessity but what he calls a 'necessity of consciousness'.

'Here are illustrations of necessity of consciousness: movement felt and internally perceived as being free can have no other cause except willed effort or the *self* which makes it begin; consequently any change undergone, any event which begins (outside the self) has a cause (not-self) which makes it begin . . . every efficient cause, even in the physical world, is an immaterial force, having a nature essentially different from its effect', etc. (p. 251).

It is clearly difficult to give an account of Biran's views in a few lines. They can be understood only within the framework of his whole philosophy, and only if we take into account the fundamental rôle which he ascribes to the 'primary fact'. The above quotations, however, are sufficient to show how far he was from a genuinely empirical approach and the extent to which he was living in the rarefied atmosphere of metaphysical speculation.

[30] TH. LIPPS, *Aesthetik*, 1903–6.

visually; and the result can be a new character in the way in which the objects appear.

Yet if we invoke this theory to explain the origin of the causal impression, there are a number of objections to it. The most obvious is its uselessness. Our research has enabled us to demonstrate the existence of particular impressions of causality in the field of external experience, and in addition to explain their distinctive character, our starting-point being the actual structure of the perceptions concerned (which in all cases involves ampliation of the movement); it would seem therefore that any other hypothesis is superfluous.

In addition this theory would not fit with the precise findings which we have been able to make as to the conditions which determine whether or not the causal impression appears. Why should the alleged projection be dependent on the speed of the objects, the ratio of their speeds, the length of their paths, the relative orientation of these paths, the length of the time-interval at the point of impact, and so on? Why should progressive changes of these variables be accompanied by qualitative alterations in the impressions? Why should projection not take place in the negative cases, which are continually interpreted in a causal way in ordinary life?

Any satisfactory reply to these questions would have to show that projection of internal experience is demanded by the perceptual data only when these data possess a special and clearly determined character. If that is so, however, one of two things must follow: either this character is precisely that of causality, in which case it does not occur as a result of projection, or it is different, in which case what is it? What is this remarkable kinematic impression which cannot be resolved into a simple experience of successive movements, and which has the privilege of evoking internal causal activity and fusing with it? And, in addition, why should this happen?

Then again, if we suppose that the internal event is *voluntary* motor activity, new difficulties arise. If this activity is to be combined with visual impressions, it must be reproduced in some way. How is this possible? Can it appear independently of the conditions which effectively give rise to a voluntary intervention? And even if this were possible, why should the result of the fusion be limited simply to the causal character, and not extend to the *voluntary* character, so that the observer has the impression that object A is *voluntarily* chasing object B?

In the last place we should bear in mind the fundamental objection

to Biran's theory, namely that the 'primary fact' is an experience of activity, not an experience of causality in the strict sense. Once this is agreed, it becomes clear that voluntary motor activity, if projected on to what is given visually, cannot pass on a character which it does not itself possess.

It should be added that the majority of the observers who took part in our experiments on causality felt themselves entirely 'external' to what went on in the apparatus. They considered themselves simply as impartial witnesses of a causal activity of a mechanical kind, which was taking place in a purely objective manner in the physical world.

This is not always so, however. Empathy sometimes occurs in the case of observers who are particularly inclined to it or are by nature especially amenable to suggestion. We have here a fact which is all the more interesting in that it enables us to state with a high degree of precision what is involved.

When they see a launching or an entraining take place, these observers feel in their limbs – in their right arms, for example – proprioceptive impressions similar to those which they feel when they themselves carry out the same sort of task. In addition they identify themselves to a greater or lesser extent with the motor object, in the sense in which a spectator at a football match or in the theatre identifies himself with one of the performers. I shall not discuss this sort of projection here, but it is important to note that it seems to be concerned only with tactile-kinaesthetic causal impressions, with mechanical causal activity and not with voluntary intervention. Thus if we take into account what was said in Chapter XIII, it is useless to look for the explanation of the causal character of visual experience in this proprioceptive impression, since the appearance of this character in the tactile-kinaesthetic field raises exactly the same problem as its appearance in the visual field. As there is no *a priori* reason why impressions resulting from stimulation of the end-organs of the muscles, tendons, or joints should be in any privileged position compared with other sensory impressions, it seems likely, as we suggested previously, that the solution of the problem is the same in both cases.

The phenomena thus require to be put in exactly the reverse order. Not only is the causal character of our visual impressions not the *result* of empathy; on the contrary it is very probable that where there is empathy, this must be explained by the presence of the causal character which belongs to visual experience. Indeed we may reasonably suppose

that it is the similarity of structural organisation which makes it possible for this visual experience to evoke the proprioceptive experience and to integrate itself with it in an overall experience of a mixed kind.

This brings out once more the inadequacy of trying to explain certain characteristics of visual perception (their spatial appearance, the presence of optical illusion, etc.) by appealing to the intervention of motor activities; these attempts were very numerous at the time when the cult of 'motricity' flourished in psychology. The principle of explanation was often more obscure than the phenomena which it was supposed to be elucidating, and in any case it itself required to be 'explained' just as much as they did.

3. THE WORK OF PIAGET

It would be very interesting to take the results of Piaget's valuable research on the origin and development of the child's idea of causality and submit them to a detailed critical examination in the light of the conclusions drawn from our own work. Such an enquiry, however, would be genuinely useful only if it led to fresh observations. These could be obtained by applying Piaget's method and by following a systematic plan of experimentation in which there figured all the different possible varieties of causal impression indicated by our own research.

An attempt can be made here and now, however, to sketch out provisionally the sort of way in which Piaget's work requires to be interpreted if his ideas and my own are to be brought into line, and attention can be called to the main points of contact between the two investigations.

The research carried out in Geneva has shown that the first causal connexions are formed very early in the life of the child and that they arise as a result of his activity.[31] Now it is obvious that the stimulus-conditions which lead in the adult to tactile-kinaesthetic perception of causality (in particular in the form of propulsion) occur even before birth, and that what is involved here is the mechanical action of one part of the body on another, or else relationships between the movements of the body and the movements of objects external to the body. It is also obvious, however, that the presence of these stimulus-conditions

[31] J. PIAGET, *The Child's Construction of Reality*, 1955, p. 315.

gives no justification at all for asserting the existence of a corresponding causal impression, and that this can arise only when a certain degree of maturation is reached. Moreover Piaget constantly and rightly emphasises the parallelism between the evolution of the idea of causality and the general mental development on which this evolution obviously depends. In particular, in this connexion, it seems that a clear segregation of impressions corresponding to the 'cause-movement' from those which correspond to the 'effect-movement' does not occur at the very earliest stage of life. On the contrary it is probable that an extreme 'syncretism' (i.e. an undifferentiated blending) holds sway at this time, and it is no doubt correct to conclude that the impression of *immanent motor activity* provides the first datum of experience as regards all this. In passing, to avoid all misunderstanding, it should be made clear that we are concerned here only with the actual *impression*, and that this does not necessarily go *pari passu* with the conceptual idea of the 'self'. The early world of the child is on this view a world essentially 'immanent' in the sense which we have given to this word; and this fits exactly with the views of Piaget.

It is clearly impossible to fix with any degree of precision the stage at which this immanence is made more complicated by the appearance of causal impressions in the strict sense, i.e. when there is sufficient segregation between the impression arising from the movement of the motor limb and that corresponding to the changes which it produces; nor is it possible to say exactly when ampliation occurs or the phenomenal duplication which characterises the causal impression. It seems, however, that this must happen during the very early stages, i.e. during the first two or three months of life, if Piaget is right when he says:

> 'When we see how, from the third stage, that is to say from the time when he can operate with his hands, the child uses his power on things and constructs a large number of causal relations between the data which fall within his perceptual field, we are forced to the conclusion that even during the first stages the subject must introduce some idea of cause into the cognizance which he takes of his activity of assimilation.'[32]

Once again it should be emphasised that this segregation is a property which belongs solely to the structural organisation of the actual sense-perception, and that it does not necessarily involve a conceptual dissocia-

[32] Ibid., p. 227.

tion between the 'self' and the 'external world', and perhaps not even any clear differentiation on the phenomenal plane between the characters of internality and externality. The causal impression is reduced to the impression of one event producing another, without the nature of the 'producer' or the 'product' being made precise in this respect.

The appearance of the causal impression does not necessarily seem to depend on the permanence of the objects, in Piaget's sense, a permanence which betrays itself in the behaviour of the child towards objects which have disappeared (e.g. in looking for them, etc.). In actual fact the length of time of permanence needed for the occurrence of the causal impression is not more than the duration of the experience itself; all that is required is that the object should remain present during the operation, and particularly when it changes from being motionless to moving or vice versa. What happens to it before or after is unimportant, as is shown (i) by the fact that in the Type-experiment of causality, when carried out by the disc method, the objects emerge from nothingness and disappear after the action, and (ii) by the fact that it is even possible to suppress the extreme phases of immobilisation (i.e. the place from which A starts and the place where B arrives) without the impression being seriously affected.

Thus the causal impression, in its most rudimentary form, appears very early, according to Piaget, and he rightly refuses to accept Hume's view as to the part played by habit in forming these first suggestions of causality; he is inclined instead to an interpretation which calls to mind the views of Maine de Biran.[33] He parts company with Biran, however, in that for him, strictly speaking, there is no question of any 'primary fact', but only of 'efficacy'. In his terminology this amounts to saying:

> 'The production of results must therefore be felt as simply prolonging the feelings of desire, effort, expectation, etc., which precede their appearance. . . .'
>
> 'The infant of one or two months . . . must thus feel the same impression, although to a different degree, i.e. that a certain action ends, without his knowing how, in a certain result, or, to put matters in a different way, that a particular complex of efforts, tension, expectation, desire, etc., is charged with "efficacy".'[34]

This recourse to phenomena of an affective order, which belong

[33] Ibid., pp. 222 seq.

[34] Ibid., pp. 227–9.

rather to the sphere of motivation, is characteristic of the theory which Piaget offers, and it is not surprising that this should have been so. It is now clear, however, that the dynamic character of the causal impression may possibly be derived from an entirely different source.

The later stage of the child's development is indicated by the establishment of 'secondary circular reactions', i.e. visual-motor co-ordination. This stage lasts from about three months to seven or eight months. At this time the child is certainly interested in causal relations, and is better able to separate out an action from its effect; but the cause apparently still remains the personal activity of the agent, while the effect is identified with the phenomenon perceived.[35]

One point in particular should be noted in this connexion. Piaget lays particular stress on what he calls the 'phenomenalism' of causal relations, which appears even in the very early stages; this means that events of any kind can be linked with activity of any kind on the part of the subject, and that such events appear in the form of 'effects' of such activity, even though there is no internal relation between them. This is revealed very strikingly by his observations, and is apparently a distinctive feature of infantile mentality. Now although it is difficult in the case of the adult to establish such links between disparate events, as we saw in connexion with the impact-noise experiments, it seems that this can occur with surprising ease in the case of the child. This is probably due to an inability to segregate and to a very powerful tendency in the opposite direction towards syncretism.

We must conclude as a result of this that impressions of activity or causality extend over a much wider sphere than might appear from what has been said earlier in this book. Indeed, whenever any sort of event occurs in conjunction with a motor activity, and more especially if it occurs in conjunction with a causal activity, such as propulsion movements made by the child on the cot or the blankets, then, provided objective factors making for unity are present, even very weak ones, there will be a chance that the event in question may become integrated in the activity or the causal impression. This may explain a large amount of behaviour which Piaget refers to under the heading 'methods of making an interesting sight last', such as those which for the child give rise to a link between bodily movements (e.g. 'arching oneself upwards') and the production of this or that external event.[36]

[35] Ibid., pp. 229 seq. and 246 seq.

[36] Ibid., pp. 238–40.

Another interesting fact which seems to emerge from Piaget's work is that the first external objects to which the child attributes a causal power distinct from his own are human beings. This must undoubtedly have some connexion with the fact that there is a similarity between the character of motor immanence which accompanies the visual perception of other people's activity and that which accompanies the tactile-kinaesthetic perception of one's own activity. Again, according to what Piaget believes he has established, it is when other people display activity that there are the first clear indications that the child is familiar with the process of triggering.[37]

When the child grows older, and it becomes possible to ask him questions, the causal explanations given by him to some of the phenomena which he observes still carry clearly the stamp of his first causal experiences; this is seen, according to Piaget, in the 'artificialist' and 'animistic' character of these explanations.[38] Here, too, the more rudimentary processes investigated in our own work suggest that this type of interpretation can easily be introduced.

Artificialism, i.e. the tendency on the part of children to suppose that their own activity is responsible for producing every kind of event in the physical world, could be explained by excessive integration. This is undoubtedly what happens when children have the well-known illusion that the heavenly bodies are moving when they themselves change position, and claim that it is they who are 'making the moon go along'.[39] The similarity of direction and speed of the movements is sufficient to link them in such a way that the movement of the heavenly bodies forms a unitary whole with the causal impressions produced by walking.

Another factor which probably also intervenes in the situation is the relationship, mentioned earlier, between motivation and causal activity (i.e. 'efficacy' in Piaget's language); and it may well be that as a result of this relationship the child is led in some cases to think that events outside him are the result of his own wishes or those of others. It should be made clear, however, that 'efficacy', according to our own theory, so far from being a basic 'given', is only a secondary product; it is some-

[37] Ibid., p. 262.

[38] While we are on the subject of children's causal explanations, mention should be made not only of Piaget's work, and of *The Child's Conception of Causality* in particular, but also of H. WALLON's recent book, *Les origines de la pensée chez l'enfant*, Presses Universitaires de France, 1945, II, Chapter 2, 'La causalité'. See also note 16, p. 13.

[39] J. PIAGET, *The Child's Conception of Causality*, 1930, pp. 73 seq.

thing which results from the closeness of the link between the desire and the causal impression proper which accompanies or succeeds it.

The 'animistic' tendency in causal explanations has been the subject of vigorous discussion in connexion not only with the thought-processes of children but also with those of primitive peoples; it is therefore worth recalling what has been said during the course of this book. There is nothing at all surprising in the fact that animism occurs as often as it does, so long as we bear in mind that the character of immanence is regularly found when we perceive movement or change in shape in physical objects – clouds, for instance, or the current of a river, waves at the sea-side, smoke and flame, and trees and leaves when blown by the wind.

There is a further interesting point in this connexion which has arisen as a result of our research. The subjects in our experiments had an amazing tendency, in describing their impressions, to make comparisons with human or animal activity. They continually used the words 'It is as if . . .' We may recall some typical examples mentioned in connexion with the Triggering Effect (p. 121), and the same thing can also be seen in simpler cases. Thus when there was an approach followed by a withdrawal, one observer said, 'It is as though after being reunited they had quarrelled and one of them went off again'; in an experiment involving pursuit one observer said, 'It is as though a policeman was running after one of the students and caught hold of him'; in experiments of launching people sometimes said that A 'gave B a kick in the pants and sent him flying'; in experiments of entraining it was regularly said that object A 'took B with him' or 'carried him off'. The occurrence of these expressions is so frequent that it must be regarded as something to note and indeed of considerable interest from the point of view of social psychology. Even if the expressions are justified by a clearly marked similarity in the combinations of movements, the question still arises as to why people feel the need to make such comparisons and to produce such interpretations in connexion with phenomena which they have often just described perfectly correctly in purely objective terms. One cannot help thinking that if these processes evoke comparisons of this kind so forcibly even in adults, then in the case of those of low mentality, whose world is obviously less well differentiated, there is probably something more than mere comparison. At any rate the ease with which operations as schematic as those of our experiments can be compared with human behaviour brings out the close relationship which exists between all

forms of phenomenal activity, and also emphasises the fact that human activity serves in some sense as a prototype for all other kinds. We should remember, too, as has often been pointed out already in this book, that human activities, both causal and otherwise, occur far more often in our experience than any variety of physical activity to be found in the inanimate world.

An intensive experimental study of these various points will undoubtedly enable the work of the Geneva psychologist to be brought to completion, perhaps with a few minor modifications. It is necessary, however, at this juncture, to stress a very important point of methodology. As a result of the remarkable astuteness of his observation, Piaget has succeeded in calling attention to various sorts of behaviour which must almost certainly be regarded as indicating certain special features in the child's thought-process, e.g. 'methods of making an interesting sight last', 'the application of familiar means to new situations', the 'search' for absent objects, the 'search' for a cause, and so on.[40] Now even if this behaviour shows that the child possesses certain ideas at the time when he makes use of them, we cannot legitimately infer from this the precise time at which these ideas were acquired, which may well be at a much earlier stage. Thus, to take an example at random, when a baby seems intentionally to place a ball in such a way that it falls when he lets it go,[41] it is clear that he must know that a body falls when not supported. But when did he learn this? The complex psychological processes involved in *the invention of this new game* perhaps develop much later and depend on a multitude of further discoveries. Moreover it seems to me in general that the intellectual powers presupposed, according to Piaget, by certain pieces of behaviour are already quite far evolved in comparison with what is required for awareness of simple cases of causality. A striking example, among others, occurs in the case of the Triggering Effect. The behaviour which constitutes the first evidence for the existence of a knowledge of the Triggering Effect might be e.g. putting a finger on someone else's lips to make him sing.[42] Now if we think of the conditions in which the original impression of triggering occurs, it is clear that these conditions arise again and again in the life of the very young child whenever an abrupt movement of retreat follows a much slower approach movement.

[40] J. PIAGET, *The Child's Construction of Reality*, 1955, Chapter III.
[41] Ibid., pp. 274–5.
[42] Ibid. ;pp. 261–2.

It is probable, therefore, that the first 'idea' of triggering is very much earlier than the appearance of the behaviour in question.

The essential condition for genuine progress in these matters is clearly the discovery of a system of more sensitive criteria, a system which would make it possible to reveal the presence of typical causal impressions, produced by combinations of movements similar to those which have been found to be fundamental in our work. This, however, would no doubt call for an altogether microscopic analysis of the child's behaviour, carried out continuously. In any case we should constantly be up against the difficulty of distinguishing behaviour which genuinely revealed the presence of causal impressions from behaviour which could be interpreted as a reflex, an instinctive reaction, or as an action in response to unconscious conditioning.

4. THE APPARENT 'SOURCES' OF THE EMOTIONS

One final question requires brief mention. We spoke in the Introduction of the link between emotions and the events which seem to produce their appearance. The part played by such events is often described in language implying the presence of causality.[43]

It should be made clear immediately, however, that this problem has nothing to do with the 'objective' conditions in which emotions are aroused; the issue is purely a phenomenal one. When an emotional state develops under the influence of factors whose nature we need not consider for the moment, this emotional state usually *has the appearance* of being intrinsically linked with a definite phenomenon, and it is *this phenomenon* which produces fear, pleasure, or pain, provokes disgust, or arouses bad temper or anger. We need therefore to examine whether on these occasions there are genuine causal impressions and why they appear in such circumstances.

Now emotions can rightly be regarded as *functional relations*, just like all the relations which we have so far considered, such as launching, entraining, approach, withdrawal, pursuit, passing over, overtaking, compressing, traction, transport, etc. Like these, emotions are *changes in an object* (viz. the self) *apparently occurring as a function of another object*, and they arise in a large number of qualitatively different forms.

Considered from this angle emotions acquire their full significance

[43] See pp. 14–15.

in connexion with behaviour, and it is easy to understand the essential part which they play in social psychology. In addition, however, the present approach supplies a methodological pointer, since it raises the question of whether the study of emotion could be helped by knowledge obtained in connexion with the perception of kinematic functional relations.

This approach seems all the more justified since there are very marked similarities, as has often been pointed out, between emotions and movements. This is exemplified by some of our habitual ways of talking, and in particular by our very use of the word 'emotion', i.e. 'movement of the soul'. Besides this there are countless familiar idioms, e.g. 'I was *struck all of a heap*', 'It *shook* me to pieces', 'I was *overwhelmed* by grief', 'I was *transported* with joy', 'I am *deeply impressed*', 'It *pierced* me *to the quick*', 'It *crushed* me', 'It *got me down*', 'It *knocked me flat*', 'I am *bursting* with enthusiasm', 'I feel *drawn towards*', 'That is *repulsive*', 'I am *stricken* with grief', 'That is *attractive*', 'That *gave me a shock*', and many others. All these terms not only have a kinematic significance; in addition they clearly imply *mechanical action*. They thus indicate once again the important part played by kinaesthetic impressions in this field, and they are evidence that the emotions have a motor character more or less similar to that which appears in obvious cases of mechanical causality, especially of the propulsion type. This does not mean, of course, that this motor aspect completely exhausts the whole phenomenal character of emotion.

If this general point is agreed, the question which we have to answer becomes precise and definite. What it amounts to is this. Is it possible in connexion with the motor aspect of the emotions to discover stimulus-conditions which, in the light of our previous knowledge, would account for the appearance of a causal impression, or at least the appearance of other functional relations of a mechanical character?

We should note at this point that the problem becomes the more complicated as a result of the evolution which our emotions undergo during the course of our lives. Such evolution arises not only as a result of 'conditioning' (i.e. transfer of emotion in virtue of which some events acquire an emotional significance which they did not originally possess), but also through the inhibition of external motor reactions under the influence of education. The conditions in which emotions arise and develop in a fairly civilised adult are often so much altered that it becomes difficult to determine to what extent expressions such as those

It is probable, therefore, that the first 'idea' of triggering is very much earlier than the appearance of the behaviour in question.

The essential condition for genuine progress in these matters is clearly the discovery of a system of more sensitive criteria, a system which would make it possible to reveal the presence of typical causal impressions, produced by combinations of movements similar to those which have been found to be fundamental in our work. This, however, would no doubt call for an altogether microscopic analysis of the child's behaviour, carried out continuously. In any case we should constantly be up against the difficulty of distinguishing behaviour which genuinely revealed the presence of causal impressions from behaviour which could be interpreted as a reflex, an instinctive reaction, or as an action in response to unconscious conditioning.

4. THE APPARENT 'SOURCES' OF THE EMOTIONS

One final question requires brief mention. We spoke in the Introduction of the link between emotions and the events which seem to produce their appearance. The part played by such events is often described in language implying the presence of causality.[43]

It should be made clear immediately, however, that this problem has nothing to do with the 'objective' conditions in which emotions are aroused; the issue is purely a phenomenal one. When an emotional state develops under the influence of factors whose nature we need not consider for the moment, this emotional state usually *has the appearance* of being intrinsically linked with a definite phenomenon, and it is *this phenomenon* which produces fear, pleasure, or pain, provokes disgust, or arouses bad temper or anger. We need therefore to examine whether on these occasions there are genuine causal impressions and why they appear in such circumstances.

Now emotions can rightly be regarded as *functional relations*, just like all the relations which we have so far considered, such as launching, entraining, approach, withdrawal, pursuit, passing over, overtaking, compressing, traction, transport, etc. Like these, emotions are *changes in an object* (viz. the self) *apparently occurring as a function of another object*, and they arise in a large number of qualitatively different forms.

Considered from this angle emotions acquire their full significance

[43] See pp. 14–15.

causal character, and since there is this clear comparison between them and emotions, this justifies us in supposing that the same holds of emotions also. Again, as we saw in the Introduction, it would seem from the expressions used to describe the links between emotions and the events from which they are derived, that these links are of many different kinds; and, since this is so, there may well be some kinematic functional relations of a non-causal kind, which likewise are comparable with the links found in the affective sphere.

In this connexion we might think for example of a characteristic impression which we have frequently met in the course of our research, that of 'coming from...' or 'arising out of...'[44] – expressions strangely reminiscent of those indicating 'origin' in the case of the emotions. It is worth while examining whether this analogy is based on a genuine similarity in structural organisation.

This organisation can be clearly indicated in the case of visual impressions, as can the conditions in which it occurs. The special requirement is that if an object is to be seen to 'arise out of' another, it should appear *in movement* close beside it, and its movement should not therefore be preceded by a phase of immobilisation. In other words the movement, as such, must present from the outset the character of a process *on the way to being completed*, a process which is incomplete at *the start*.

The same seems to be true of emotion considered independently of its context; it too appears as a process which is *incomplete* when it originates, and which for that very reason, like movement, has a definite tendency to become attached to something which is stable or at least has been stabilised. If we accept that there is such a tendency, may it not be the case that, when an emotion arises at the same time as the appearance of another event, this is sufficient to ensure a link between them, a link which then necessarily takes the form of 'arising out of'?

This is clearly only a hypothesis – indeed an imprecise and tentative one which considered in isolation seems somewhat fanciful. Moreover one could easily think up many other hypotheses to account for possible types of link between emotions and the events to which they relate, but such suggestions would remain for the moment as inconclusive as the one which I have just made.

[44] See note 3, p. 167, exp. 95 (appendix I), and A. C. SAMPAIO, op. cit., p. 15.

implying causality are not the relic of phenomena which originally appeared in a very different form from that which they assume later. We must also take into consideration other aspects of the total state of the person – feelings of pleasure or displeasure, and, in man, his 'mental attitudes', such as consent, opposition, etc., when integrated with his emotions – which as a result of their character of 'intent' perhaps play a part in connecting the emotion with its 'source'.

However that may be, it seems that, at least in some cases, the actual conditions in which motor reactions characteristic of the emotion develop are of a kind to give rise to a genuine causal impression. Thus when a person suddenly pushes his fist in another person's face, and the second person makes an instinctive withdrawal movement, we find a situation quite similar to that of the Launching Effect. The fist of the assailant constitutes object A and the body of the person attacked object B; the movements performed by both parties are more or less in temporal contiguity; they are in the same direction, and the polarisation of the second is clearly inverse.

It is thus quite natural that the movement of the fist and the withdrawal movement should be integrated in a causal impression, and, since kinaesthetic impressions constitute an important aspect of the emotion of fear, that this emotion should seem to be produced by the attacking movement.

In other cases the events to which the emotions belong do not have so clear a kinematic character, but even then they go some way in that direction. Thus when a stretch of country is suddenly lit up by a violent flash of lightning, this situation can give rise to a reaction of retreat and fear. Perhaps gamma movements may play a part in this case, as they do in exp. 73 (p. 231); and possibly something similar occurs when there is a sudden loud noise. Again there is an undoubted similarity between the evolution of a musical phrase or a whole symphony, or the development of a speech to its climax, and the impression given by movement in the strict sense Moreover the course of the emotions and the kinaesthetic reactions of the audience take on literally the same *pattern* as the 'movements' in the melody or lecture. Is there not here, too, a sort of causal impression of the propulsion variety?

It would be a hopeless task, however, to try to discover 'movement' in all events which are antecedent to emotions, for it is only too clear that these events by no means regularly have a 'motor' character or aspect. Moreover since many kinematic functional relations have no

APPENDICES 1 AND 2

It seems to me, however, that the few ideas mentioned in this section constitute in their entirety a more serious argument, and that it would be very interesting to make a detailed study of emotional reactions and 'objective' functional relations along the same lines as we have followed in this book. Such an investigation might perhaps be expected to throw some light on the whole subject of the affective life, which has always been such an enigma.

APPENDIX I

A Special Case of Propulsion: the Trace-making Effect*

During some further research we investigated a form of causality which from the point of view of structural analysis is very curious, viz. the situation where an object in passing over a surface leaves a trail, stain, or mark on it, or draws a line there. Among examples may be cited the use of a pencil and the use of a paint-brush.

This phenomenon is of special interest in that it must undoubtedly have occurred as one of the original conditions for the invention of writing, while the opposite phenomenon, that of erasing, must necessarily constitute the experiential basis of the various methods of cleaning.

For us, however, its chief point of interest lies elsewhere. It is the only case which we have met so far in which it would seem possible for the causal influence to bring about the *creation* or *destruction* of matter. Now such a case is likely to raise major difficulties of interpretation, and in particular to cast doubts once more on our whole theory of the causal impression. It was for this reason that a serious examination of the problem seemed to us indispensable.

When we try to produce the phenomenon of trace-making in simple experimental conditions, we come up against a number of difficulties. Thus the occurrence of a trace always implies that one object (the trace itself), while adhering to another object (the object making the trace), becomes larger in physical size; and this pattern of stimulus-conditions can give rise to an amazing variety of impressions, according to the different ways in which the experiment is performed and the different attitudes which observers take up. Moreover a trace in the strict sense can occur under two specific forms, only one of which is causal; and what makes things even more complicated is that there is a tendency to pass from one form to the other during the same experiment if this goes on for any length of time.

1. THE CAUSAL TRACE EFFECT†

Here is a description of the experiment which we found to be the most satisfactory.

*L'effet traçage. See Glossary. † Le traçage causal. See Glossary.

Many of the subjects spontaneously indicated a parallel with writing or the use of marking-ink, or made a comparison with a paint-brush. When they were then asked whether there was any causal influence, they replied without any hesitation that they saw A actually 'produce' the trace.

Of the other subjects, three said that B 'came out of' A 'like smoke from an aeroplane' or 'like an object falling off a travelling lorry'; two of them gave predominance to B, saying that they saw it appear, expand, and 'throw off' A; and one of them saw A simply 'uncover' during its journey some motionless black objects drawn on the background.[2] All these impressions are clearly very different from that of a causal trace, and will be discussed later.

When they tried the experiment over again, several of the subjects wavered between one or other of these impressions, and as a result they were able to recognise in a very clear way the difference between the Causal Trace Effect in the strict sense and other results.

The experiment was repeated with a further twelve new subjects, and a few variations in the experimental conditions were introduced. There were six further cases (50%) of a clear Causal Trace Effect, three cases in which object A disclosed object B, two cases in which subjects saw B 'come out of' A, and one case in which A and B were independent. It seems that, if no clear instructions are given about fixating object A, the result is to favour the Screen Effect, and conversely that, if the height of the slit is reduced to 1·5 mm. (instead of being the usual 5 mm.), the result is favourable to the Causal Trace Effect. This seems quite logical, as will be seen later.

Having established reasonably clearly that there exists a causal impression of trace-making, we must now consider in detail a number of special characteristics belonging to the experience in question.

1. In all our other experiments objects A and B normally had a similar phenomenal character, in the sense that they both possessed the property of being a 'figure' set against a 'ground', and, as a result of their movement, even appeared to some degree as tangible 'things'. In the present case, however, this is not so. B loses its autonomy and seems to adhere to the background like a layer of colour; it becomes

Exp. 91. Object A is a red square of side 5 mm., placed at the extreme left of the slit. It moves towards the right at a speed of between 1 and 3 cm. per sec., and passes with a uniform movement along the whole length of the slit.

When it has moved a distance of 3 cm., a black strip of the same height (object B) begins to appear at the rear end. This strip does not move at the left-hand end, but it gradually increases towards the right at the same speed as object A. This procedure continues until the total length of B is 15 mm. From then onwards B does not undergo any change, but A separates from it and continues to move. The operation can be repeated two or three times during A's journey along the slit; and at the end there remain two or three separate black rectangles spaced out on the white background.

When the disc is turned the other way, the experiment begins with object A at the extreme right of the slit, along which are to be seen one or several black rectangles – objects B. A moves towards the first rectangle, and at the moment when it touches it, this rectangle gradually starts to decrease in length, beginning from the right-hand end and finally disappearing completely while A continues its forward movement towards the left.

If the experiment is to succeed, it is important to ensure the dominance of A; and it is for this reason that its movement begins before B starts to appear. The subject must also be asked to fixate object A and follow it with his eyes as it moves.

In the great majority of cases the results of this experiment are clear. Object A seems to *write*, to *draw a line*, or to *paint* like a paint-brush; and when the experiment is reversed it seems to *erase*, *swallow up*, or *destroy* object B.[1]

All the experienced subjects had no doubt that there was a causal impression. In addition the trace experiment was repeated with twenty-six new subjects (students) who had no idea of its purpose. Nineteen of them (73%) described their impressions in a way which left no doubt as to the kind of impressions that they were. They said, for instance, that A was 'making marks', 'drawing a line', or 'spreading a layer of grease on the surface'. Two subjects saw object B as a 'hole' in the background surface, and said that A was 'making the hole as it went along, as though it was fitted with a cutting edge'.

[1] To avoid making this appendix too long I shall be concerned in a systematic way only with the Trace-making Effect. It is worth adding that the Erasing Effect appears to be simpler from the structural point of view, but that in other respects, in spite of certain differences (especially with regard to the phenomenal character of 'object' B), most of the points made in connexion with the Trace-making Effect apply also to the Erasing Effect.

2. A striking characteristic of the Causal Trace Effect is the *apparent lengthening* of B; and it is something absolutely essential, since it is the very presence of this 'movement' of growing, which by producing the conditions of an actual *propulsion*,[3] makes possible the formation of the causal impression.

The lengthening of B takes place in the same direction and at the same speed as the forward movement of A, and the two objects remain in spatial contact. On the other hand, the movement of A occurs *before* the appearance of B and is therefore dominant. The result is that all the conditions which we know from earlier experiments to be necessary for ampliation of the movement are once more found together, that B takes on the character of 'participating' in the movement of A, and that there must necessarily be a causal impression.

Again, it is easy to show that the impression of lengthening is indispensable for the production of the causal impression, since in its absence the causal impression disappears. In particular this happens when B becomes more than a certain length and the result is the Emanation Trace Effect (see later), or in the conditions of exp. 95, or again in the following experiment.

Exp. 92. This is the same as exp. 91 except that object B is reduced in size and is simply a vertical line 1 mm. thick.

This experiment was performed with several experienced subjects and five new ones, and the results are in full agreement with the claim made just now. Some subjects saw a black line appear 'by chance' at the moment when A moved across; others saw this line become detached from A at some point on its journey. In no case was there any 'production' of B by A. B, incidentally, tended to look like a thin 'object' of the same kind as A, and not simply like a line drawn on the background.[4]

The fact that a lengthening of B is necessary if the causal impression is to be produced is in full agreement with our theory. Ampliation is inconceivable in the absence of movement, and there is thus no means by

[3] Propulsion Type II. See p. 172 and pp. 177 seq.

[4] It seems from a number of preliminary observations that the length of B must reach at least 4 or 5 mm., in the conditions of exp. 91, if the Causal Trace Effect is to appear. The length of object A also has some influence on the success or otherwise of the experiment. We cannot stop here to consider this question, however, which seems to be connected with the problem of the centre of reference of object A's movement and with the problem of the radius of action.

If the height of the slit is reduced, this favours the impression of lengthening, and hence also the Causal Trace Effect.

simply a 'trace', or even appears to be an alteration in the background itself, e.g. an opening cut in it.

What, then, are the stimulus-conditions which give rise to this special feature? We do not yet possess sufficient data to determine them fully, and to achieve this a systematic study would be necessary. One point is clear, however. It is not the causal character of the impression of trace-making which is responsible, since the same thing happens in exp. 94 (see below), when the result is a simple Screen Effect. This point is of particular interest, because the feature is certainly not due in this case to the Screen Effect as such, which, generally speaking, is perfectly compatible with conditions where there are two 'things', one of them sliding in front of the other.

There must therefore be some factor common to expts. 91 and 94, as a result of which B takes on the character of being a trace. Now the only factor which can be relevant is that B, without any forward movement of its own, appears immediately behind A during A's movement, and increases in size as A goes forward. It would seem, then, that these conditions are particularly favourable to a loss of substantiality by B. (These are not in fact the only conditions, as will be seen from exp. 95, which in this respect is similar to exp. 91, but in which the character of being a 'trace' is lacking.)

All this may seem surprising, since people are inclined to assume uncritically that characters such as that of being a 'trace' or a solid object are bound up with combinations of stimuli which correspond to the objects themselves. Thus one might suppose that the 'trace-character' possessed by a pencil-line arises because the stimuli are of a kind to make us see on the same plane as the paper a line without any thickness, while the pencil appears as a three-dimensional solid.

Now in exp. 91 the situation is quite different. The stimuli corresponding to the objects are identical, and the objects differ in phenomenal character only as a result of the integration of these stimuli in a particular kinematic system.

Earlier research, particularly the pioneer work of Katz on the phenomenal character of colours, that of Rubin on the figure-ground distinction, and that of their successors, had already led to conclusions which were similar in principle. The present case, however, is especially striking because the determining factor, being of a kinematic kind, seems somehow to be more external, more contingent, in relation to the objects, than is the spatial structure of the field.

Exp. 93. In this experiment object A, a black square of side 5 mm., is in the left-hand part of the slit at a distance of 5 mm. from object B, which is a red rectangle 15 mm. long.

A begins to move towards B at a speed of between 1 and 3 cm. per sec. It passes *in front of B* (*as in exp. 56, the traction experiment,* p. 160), and when its left-hand end reaches the right-hand end of B, B *lengthens at the same speed* as A and remains attached to it. This continues until B has reached a total length of 30 mm. (or 45 mm.), and the two objects then stop. (Alternatively A can then be made to separate from B and continue in movement.)

In spite of the great similarity between these experimental conditions and those of exp. 91, there is no longer any Trace-making Effect; usually the impression is one of object B being *stretched* (a passive form of dilatation) by object A. A, as it passes, hooks on to the front end of B as in the traction experiment, but since the rear end of B stays *still*, it appears that B is being stretched like a piece of elastic.

Thus the pre-existence of a part of B makes for B's permanence and substantiality, *and as a result the causal impression takes on a character* quite different from that of trace-making.

Another variant of exp. 91 consists in eliminating the dominance of object A by suppressing the phase of its movement which precedes B's appearance.

Exp. 94. Object A, a red square of side 5 mm., is present on its own, and is *motionless at the centre* of the slit. At a given moment it begins to move to the right at a speed of between 1 and 3 cm. per sec.

At the *same moment* a black strip of the same height, object B, begins to appear at its rear end. The extreme left of this strip remains *motionless, while the strip* itself gradually lengthens towards the right at the same speed as object A. This goes on until its total length is *15 mm. It then stops completely,* while object A separates from it and continues to move for a distance of 3 or 4 cm.

This experiment was carried out with eight new subjects. Six of them had *an impression of the Screen Effect* kind.[7] They saw object A move towards the right and gradually *uncover* B, which appeared to them to be

[7] The Screen Effect seems to be the normal result from these conditions, as is shown *by Sampaio's* research. Two of the new subjects, however, and the few experienced subjects who performed the experiment had the *impression* that object B actively dilated and pushed object A away. This structural organisation clearly implies the dominance of object B, and *it* reflects a *special observational* attitude which among the trained observers must have been favoured by earlier experiments.

which a *creation of matter*, as such, could ever give rise to a perception of causality. What is more, it is interesting that the descriptions given by observers contain no allusions which can be interpreted in a causal sense; they refer only to processes of a kinematic character. Thus in the case of the trace experiment no one says that object A is producing the black colour but that it is *spreading* it or is *making holes* in the background. There cannot therefore be any question here of a creation of substance, as a superficial study might have allowed us to suppose; strictly speaking there is a creation only of 'movement'.[5]

3. The impression of lengthening, whose importance we have just noted, is of a very special kind.[6] It is quite different, for instance, from the *dilatation* which occurs in some experiments (see pp. 67 and 74). In the case of dilatation the total quantity of matter which makes up the object remains constant, and the increase in size seems to take place by means of an internal separation movement (see p. 198). Nothing comparable happens here. As soon as B begins to come in sight, the end of it becomes fixed or 'stuck' to the background, and there is then a gradual *addition* of matter, each new piece becoming motionless as soon as it appears; in other words object A gradually 'deposits' something on the background, a piece of matter which in its own nature is motionless.

The difference between the impression of 'unfolding' and that of dilatation is immediately obvious if we compare exp. 91 with the following experiment, which is similar to it except that object B is present from the start.

[5] In the case of the Erasing Effect the situation is analogous in that the *shortening* of B also takes place in the same direction and at the same speed as A's forward movement. This of course makes possible the appearance of a causal impression of propulsion.

There is, however, a difference between the two cases in that, in the erasing experiment, B is present from the beginning and is usually an 'object' of the same status as A. Consequently there is in this case a suppression or annihilation of 'matter'. No special difficulty seems to be created by this, however, so long as it is agreed that the causal impression is produced primarily by the combination of 'movements' and not simply by the fact of annihilation as such. There would be precisely the same difficulty in the case of the Trace-making Effect if this involved the impression of a genuine 'creation' of 'matter', which it does not.

[6] It is related genetically to the Unfolding Effect, of which it is a passive form. This effect can readily be observed when someone suddenly unfolds a fan, for instance.

a mere coloured strip painted on the background. This feature of the impression was pointed out in a particularly striking way by one observer who, when asked in the ordinary way to describe 'what was going on in the slit', mentioned only object A and its movement, without making the least reference to B. When questioned he said that that was *all* that was happening. When he was asked expressly if there was not also 'something black', he said that of course there was, but it was an unimportant detail belonging to the background in front of which A was moving!

This is a striking demonstration of the great phenomenal difference between the character of being a trace and the character of being an object. In addition, the results of this experiment, taken together, bring out once more the crucial importance both of the priority of A's movement and of A's dominance in forming the right structural organisation for an impression of causality.

4. In spite of the differences between lengthening, as it occurs in the Trace-making Effect, and increase in size occurring as a result of stretching, these two structural organisations nevertheless possess some features in common, in particular an *internal centre of reference*.

It is clear that any impression of increase in size, of whatever kind, presupposes a change in the object in relation to itself; at the very least there is an increase in the distance between its extreme ends.

This has an important consequence which seems to be connected with the *radius of action* of moving objects. We saw in Chapter IV that an object which approaches or withdraws from another is referred to it phenomenally only within certain spatial limits, which vary according to the speed. Now there are numerous indications that the same holds in the case of lengthening and shortening in size, and that these too become established only when there is a certain distance between the ends of the object. It would thus seem that we are justified in speaking of a radius of action in this connexion also.[8]

The existence of a radius of action of this sort would account for the fact that the causal impression of trace-making is clear and consistent in exp. 91 only if B's length is limited to 30 or 40 mm. at the most. This length, according to our hypothesis, would represent the maximum extent of the radius of action for the range of speeds adopted, and the overall *impression of lengthening* on the part of the whole object would

[8] See A. C. SAMPAIO, op. cit., p. 21.

pression and another. If, however, we take into account all the data from repeated experiments in which these subjects took part, the results are found to be the opposite of those which occurred in the case of exp. 91. Only four subjects (25%) made any clear reference to a Causal Trace Effect; four others saw the ordinary Screen Effect, with object A gradually uncovering object B which was there already; and only one subject said that object B pushed object A (a result implying the dominance of B).

In contrast, twelve subjects (75%) said that they saw B 'come out of' A, without implying that A was exerting any influence on B's coming out. Some of them added that it was 'like toothpaste' (three subjects) or 'like glue' (also three subjects) 'coming out of a gradually receding tube'.

The descriptions given by the subjects bring out clearly the almost complete absence of any 'trace' character in this experiment. We cannot therefore regard it as having any direct bearing on the Emanation Trace Effect. Indeed object B seems normally to be of the same nature as object A, to be just as 'palpable' and just as much separated from the background.[9] Apart from this difference, however, the phenomenon of emanation which occurs here is related to that which can be observed in the Trace-making Effect proper, as we showed by performing experiments based on exp. 91, but with B reaching a length of 80 or 90 mm. The use of the projection method carried the advantage that the impression was given in a purer form, since the Emanation Effect was not preceded by a causal phase, and was thus better isolated and easier to observe.

The chief characteristics of the Emanation Effect as it occurred in this experiment can be summarised as follows:

1. There is no *impression of lengthening* in the strict sense. Admittedly we can see the matter which comes out of A join the 'mass' which was there before, and 'continue' it, or rather 'prolong' it, but this mass no longer looks particularly like a unified whole, and the fixed end-piece no

[9] It should be made clear that the reason for this cannot be anything to do with the Emanation Effect as such, since the same thing is also found in all genuine cases of trace-making when the trace is sufficiently long. It seems rather that it is the phenomenal look of the 'matter' comprising the 'object' which is involved here. There is undoubtedly too great an opposition between the 'film' character of projected colours and the 'surface colour' of the screen for the former to 'belong to' the latter, or adhere to it, a condition which appears to be indispensable if B is to lose its substantiality.

case of ordinary writing, the visual impression of trace-making is normally only of the causal kind, whereas if a long line is drawn and we follow with our eyes the point of the pen or pencil, the trace-making impression quickly evolves towards one of the emanation kind.

This evolution, occurring as it does during the course of an operation which one tends to regard as continuous and uniform, makes observation difficult at the beginning because of the contradictory nature of the results; and it is only if we take account of the existence of different stages that the matter becomes fully clear.

The Emanation Trace Effect is nearer to an emanation in the ordinary sense than is the Causal Trace Effect. It is therefore interesting to examine the phenomenon of emanation with some care in order to understand better this second form of trace-making.

This phenomenon can be produced in a way that is very suitable for study if we carry out experiments similar to exp. 91, using the projection method. Here is an experiment of this kind.

Exp. 95. A white object, object A, is projected on to a fairly large screen which is faintly lit. Its shape is that of a symmetrical trapezium, placed so that its two parallel sides, of 4 mm. and 15 mm. respectively, are vertical and so that the shorter one is on the left. The horizontal distance between the sides (i.e. the width of the trapezium) is about 20 mm.

This object moves off at a speed of 1 cm. per sec. and travels towards the right.

When it has covered 3 or 4 cm., a red strip 4 mm. high begins to appear, as a result of a special device, at the left-hand side of the trapezium. The left-hand end of this strip is fixed, but it gradually increases in size towards the right at the same speed as the trapezium and remains in contact with it. This is object B. The operation continues until the length of the line is 9 or 10 cm., after which the combined whole stops permanently.

This experiment was repeated a large number of times with two experienced subjects. The results were somewhat variable as long as the observation-conditions, the size of the objects, etc., were not strictly controlled. The experiment was then repeated with sixteen new subjects, who were asked to fixate the left-hand side of the trapezium, and the projected images were given the size indicated above.

In spite of these precautions, the impressions were still not entirely stable, and some subjects mentioned alternations between one im-

4. The Emanation Effect is clearly very similar to the Screen Effect, of which it may be regarded as being a somewhat special form. In the case of emanation the necessary presupposition is that the line of demarcation which separates A (the 'tube') from B (the 'toothpaste') belongs exclusively to object A, since if B were limited or halted at this point it could not appear to 'come out of' A. This is precisely what happens in exp. 93.

In the case of the Emanation Effect, however, the situation is complicated by the fact that the two objects are related to each other as *container to content*. This leads to the very curious, indeed paradoxical, conclusion that it is the 'hidden' part of B which is prolonged phenomenally in the direction of object A and which seems to be 'included' in object A, even though there is no corresponding stimulus where this is happening.

At this point, of course, the perennial objection can be raised that what is involved here is not a phenomenal datum but merely an interpretation of what is 'given', made on the basis of acquired knowledge. The experiments of Rubin, Sampaïo, and others, however, as well as many observations made during our present research, are in flat contradiction with this view; indeed the matter is so well established that it scarcely deserves mention. The Screen Effect is a phenomenal datum *sui generis*, just like the causal impression, etc.; and its simplest form is clearly that which occurs when we distinguish between figure and ground in such a way that the figure is seen to be situated in front of the ground and seems to cover it. The experimental conditions in the Screen Effect give rise to the formation of a structural organisation in the third dimension, in the sense that the screen appears to be placed in front of the background against which it stands out, or in front of the object over which it slides, or which slides behind it. The Emanation Effect, as it occurs in exp. 95 or as takes place when water is seen coming out of a tap, or a liquid is seen flowing from the neck of a bottle, differs from the Screen Effect only in that its organisation is a little more complex owing to the induction of movement and thus to the structural organisation of the Emanation Effect.

Again we should not exclude the possibility that an emanation, or even an Emanation Trace Effect, may 'participate' (in the sense given on p. 257) in a mechanical causal activity. It is thus possible that, when a long line is being drawn with a pencil, the Trace Effect participates in the causal impression of propulsion which arises from the fact that the object is being handled. Again, in the case of toothpaste coming out of a tube when we squeeze, it is possible that the impression of 'coming out of' becomes taken up in the activity of compressing.

longer acts as centre of reference in the total organisation. In addition the phenomenal centre of gravity of the perception has been shifted; pride of place is given to the things happening around object A.

2. As in the Causal Trace Effect, there is here an immediate *immobilisation* of B's matter as soon as it has come out of object A.

3. The impression of 'coming out of' nevertheless involves a *movement* by B, although it is limited, and strictly confined to the immediate edge of object A.

The characteristics of this movement are its direction, which is the opposite of that of A's movement, and its inverse polarisation, i.e. it is referred to object A, from which B 'comes out', with A isolating B from the external framework.[10]

The movement of B can easily be understood when real objects are involved, e.g. toothpaste coming out of a tube, since in this case there is an increase in the distance between the visible irregularities in the paste and the mouth of the tube; and because the tube acts as centre of reference it is the toothpaste which seems to be in movement and to emerge from the tube. Since, however, such irregularities were excluded as a result of the apparatus used, the only possibility in our experiment is that there is an *induced movement*; and its occurrence is all the more curious since the part of the object which seems to move cannot be distinguished from the motionless part in any respect except by the very fact of its movement.[11]

Whatever the origin of B's movement, the important thing is that it occurs and that it is in the opposite direction to that of object A. It follows, if our theory is correct (see pp. 103 and 219), that *the Emanation Effect cannot exhibit any basic causal character* in these conditions; and indeed it does not.[12]

[10] It is clear that if B's 'movement' were referred to the external framework, it would appear to take place in the same direction as A's movement, since the lengthening also takes place towards the right of the frame.

[11] Induction of movement can also operate when the objects are real ones.

[12] The question also arises as to why the Causal Trace Effect occurs so rarely when the experiment is carried out by the projection method. The size of the images is certainly not an operative factor, since we made them equal in size to the objects used for exp. 91, and this had no influence on the results. As a result we are reduced to mere conjecture. It seems probable *a priori* that the phenomenal look of the images (see note 9) has something to do with the result. Possibly also the fact that the two objects look similar is particularly favourable

colour' and during the second we see it '*leave a trace* behind it' ('*spread*' here indicates an active causal intervention, while '*leave*' is only a sort of detaching or abandoning with nothing causal about it).

The structural organisations of the two phases, as we have found, are similar in a number of ways; but the first is more complex than the second, and degenerates into it when the impression of B's lengthening (relative to its starting-point) is destroyed and the character of causality vanishes. In effect, what happens is this; as a result of the operation being prolonged, there occurs an evolution which in some respects is reminiscent of the evolution examined earlier (Chapter IX), in which the Transport Effect is substituted for the causal impression of entraining.

As can be seen, the Trace-making Effect is extremely complex and raises a vast number of questions. Indeed one cannot but feel astonishment, tinged perhaps with some amusement, when one thinks that the whole business concerns something as commonplace as the stroke of a pencil! – indeed not even that, since the schematic character of our experiments obviously involves a great simplification of the situations to be found in ordinary life.

However that may be, the study of the Trace-making Effect has made an appreciable contribution to our work as a whole. Not only has it enabled us to confirm once again the validity of our theory of the causal impression; it has also enabled us to make a number of points more precise, and provided some new facts which in their turn raise very interesting problems. For these reasons I felt justified in adding this appendix to the account of our earlier research on the perception of causality, rather than waiting to include it in some later publication.

plicated; one object is contained in the other instead of merely being localised in a different spatial plane from it.

Let us now return to the Emanation Trace Effect in the strict sense. Where there occurs an emanation from a fixed object, it is usually the case that the moving object, i.e. that which 'comes out of' the other, is dominant because of its state of movement. When the container is itself in movement, however, an opposite kind of hierarchy can be established under the influence of certain factors. This is clearly what happens in the Emanation Trace Effect in particular – a point which we can understand if we observe it directly, e.g. as it occurs in one of the variations of exp. 91, where B is lengthened over a considerable distance.

The temporal priority of object A's movement and its causal rôle in the first phase of the experiment give it a clear supremacy over B; and this supremacy is no doubt reinforced by the 'trace' aspect of B in this experiment. In these conditions the trace is merely an accessory connected to the object making the trace. It 'belongs' to it in the same way as indices in arithmetic or algebra belong to the letters or numbers to which they are attached. This is certainly a distinctive feature of the Emanation Trace Effect; the trace appears as the object's trace, as 'something' *belonging* to this object.

The importance of this 'belonging' can be demonstrated if B is made completely autonomous. This can be done by altering exp. 91 in such a way that B, when it appears, possesses a movement of its own in a direction opposite to that of A and noticeably faster. In that case we see B come out of A, but in a much more independent way than it does in the Trace-making Effect, and in a way that recalls the puffs of smoke which come from a steam-engine.

The dominance of object A also has the further consequence that the Emanation Effect in its pure form is obscured. It no longer appears as such, but it is suggested in the distinctive character of the overall impression, which can be very accurately described by saying that object A '*leaves a trace* behind it'. This expression brings out clearly the 'trace' aspect of the impression and also indicates the source from which this trace comes.

If we link up this conclusion with what was said in connexion with the Causal Trace Effect, the whole picture becomes clear. During the first phase of the operation we see the trace-making object '*spread* the

were added at a later date.[1] The present exposition will be briefer, but expresses my own position in perhaps a more adequate way.

In research such as ours the experimenter has at his disposal two sources of information.

In the first place there is the 'experimental situation', comprising the system of stimulus-conditions and capable of being defined in physical units measurable by instruments. Thus when in describing my experiments I speak of patches of colour, etc., the underlying assumption is that, if one wanted to, one could specify the colour by a spectral analysis; and similarly the size and geometric shape of the objects presented, the distance between them, the direction and speed of their movements, and the observation-distance are defined in terms borrowed from the physical sciences—centimetres, seconds, etc. All this clearly belongs to the sphere or 'world' of physical science.[2]

The second source of information comprises the verbal responses of the subjects; and this point requires careful examination.

1. It should be made clear at the start that I have never asked my subjects to adopt the 'attitude of introspection' which formerly provoked such sharp discussion. Their instructions were: 'Say simply what is going on in the apparatus' or some equivalent wording such as 'Say what you see in the apparatus'; and to make the position clearly understood they were told also that the description should be such as one might give when witnessing any sort of event in ordinary life, and should be given in as spontaneous a way as possible.[3] When we wished

[1] See A. MICHOTTE, Psychologie et Philosophie, *Revue Néo-scolastique de Philosophie*, Editions de l'Institut Supérieur de Philosophie, Louvain, 39, 1936, 208–228 (particularly pp. 213 seq.). See also Réflexions sur le rôle du langage dans l'analyse des organisations perceptives. *Proc. XVth Int. Cong. Psychol.* (Brussels, 1957), North Holland Publishing Co., Amsterdam, 1959, 17–34.

[2] When I use the word 'world' it is in the same sense as one might speak of 'the world of finance' or 'the world of the theatre'.

[3] H. E. Gruber and his collaborators have made an interesting observation in this connexion. They used a device which was so arranged that a lever, one of whose ends appeared to rest on a support, was held in position horizontally by an electro-magnet hidden out of sight of the subjects. The removal of the support never brought about the fall of the lever, which occurred only when the current of the electro-magnet was broken; this was controlled by the experimenter. It was thus possible to vary the time-interval between the removal of the support and the fall of the lever. In a series of experiments, in which the subjects knew about the apparatus, it was made clear to them that it might sometimes seem as if the lever fell because of the removal of the support, and they were asked to say when they received this 'impression', although they knew that really there was no causal relation. In a second series other subjects were

APPENDIX II*

Theory of Phenomenal Causality
New Perspectives

THEORETICAL PROBLEMS

Fifteen years have now passed since this book first came out in French (1st edition, 1946; reprinting, 1954). It has given rise to a considerable amount of research both at Louvain and elsewhere, some of which has now been published. (For details see *General Bibliography*, pp. 416–419).

As a result we are in possession of many new facts; and in the light of these my earlier theory about the perceiving of causality can be reformulated. The publication of a translation of the book into English has provided a good opportunity for setting out the theory in its revised form. In addition it seemed to me that, if the exposition was to be fully adequate, a clear statement was called for of the standpoint which I personally have adopted in my own research. The following pages have been written with this twofold objective in mind.

I. GENERAL CONSIDERATIONS ON METHOD

When the book was first written I adopted the terminology which was then in use among many psychologists, particularly those of the Gestalt school. It seems, however, that in spite of precautions which might have seemed sufficient at the time, certain expressions—certain turns of phrase, perhaps—are of a kind which could give rise to misunderstanding about my approach on the theoretical side to problems of perception.

For this reason I should like in what follows to make clear the viewpoint of phenomenological psychology (or experimental phenomenology) as I understand it.

This viewpoint was put forward in outline in a work published before the first edition of *La Perception de la Causalité*, and further details

* Written in 1961. The French version of this appendix occurs in *Causalité, Permanence et Réalité Phénoménales*, *Etudes de Psychologie Expérimentales*. Studia Psychologica, Publications Universitaires de Louvain (1962).

This result is clearly due to the fact that between stimulus and response there intervenes a whole series of psycho-physiological processes which develop in the receiving organism, which become elaborated there, and which determine the way in which the physical world appears to the subject, or in other words determine his 'phenomenal world'.

It is of course from phenomenal data that the physicists' 'world' is constructed. It is quickly made independent from its origins, however, by counterchecks and by increasingly delicate controls which make possible the creation of its own concepts and the formulation of its own laws and which eventually after a vast intellectual effort make up the edifice of the physical sciences.

To avoid all possible misunderstanding, it should be made clear that when I speak in what follows of physical events or of the physical 'world', I shall always be referring to the world of physical science, the physicists' world.

3. As for the processes constituting the phenomenal world, they are clearly inaccessible to the direct inspection of the experimenter. He does not know how the subject sees the physical situations with which he is confronted; they are unknowns x, y, z, which he can hope to discover only indirectly by observation of behaviour, and among other means by the interpretation of the verbal responses of his subjects.[5]

As far as our problems are concerned, it is thus essential to know to what extent and by what means it is possible to use verbal responses for this purpose.

It is of course quite wrong to say that their rôle is to suggest to the experimenter that what the subject 'sees' is the same thing as he himself sees when he uses the same verbal descriptions. Such suggestions would be of no value at all, since they admit of no control and would thus constitute only a futile game.

It is very different, however, if we treat spoken words as 'differential responses' enabling us to know whether in particular experimental conditions a subject does or does not perceive a particular event x.[6]

[5] Throughout this book there often occur expressions such as 'what the subject sees', or 'the impression received by the subject', and so on. These expressions are clearly only abbreviations, and are used to make the text less cumbersome. They in fact refer to the subjects' verbal responses and they therefore mean 'what the subject says or asserts that he sees' or 'that of which the subject says or asserts that he has an impression', and so on.

[6] A. MICHOTTE, Psychologie et Philosophie, op. cit., p. 216.

to obtain fuller information, the only questions which we allowed ourselves to ask were ones such as 'Could you not put it another way?', 'Could you not be a little more precise?', or 'Could you not give me a few more details?', with all traces of suggestion carefully avoided.

Now the responses in these conditions given by the subjects always relate, of course, to the physical 'world', except when they mentioned e.g. the degree of certainty attaching to their observations. But the physical 'world' in question here is no longer the world of physical *science*, as revealed by measuring instruments; it is *the world of things, as it appears to the subject* on simple inspection, his 'phenomenal world', disclosed in this case by the indications which he gives as a human 'recording instrument'. Thus when he says that A 'pulls B' or 'pushes B', he is referring to an event occurring in a world which appears as external to him, an event of which he thinks himself simply a witness and which he is merely describing. For the naïve subject there can be no doubt about this, since he is convinced that what he sees is 'really' happening and that he sees it *as* it is really happening, just as he is convinced of the existence of sounds and colours 'in themselves'. When the subject is aware of the situation and is familiar with the apparatus used in our experiments—discs, projectors, etc.—he still says that he 'sees A push B' even though he knows that this is not what is 'really' happening.[4]

2. In general the verbal descriptions given in ordinary life correspond satisfactorily with the physical situation as determined by measuring instruments; and this reflects the fact that our behaviour is adapted to the environment in which we live.

Sometimes, however, there is no such correspondence. In addition it often happens, especially in laboratory conditions, that the same situation gives rise to different and even mutually exclusive responses, either with different subjects or with one and the same subject on different occasions. This is what happens in cases where the stimuli are ambiguous.

asked to say whether the lever fell because of the removal of the support or because of the breaking of the current. Now the authors observed no appreciable difference in the results whether the subjects concentrated on what was given phenomenally or considered the physical cause of the fall. In both cases the responses were determined by the temporal relationships of the events. See H. E. GRÜBER, C. D. FINK, and V. DAMM, Effects of Experience on Perception of Causality, *J. Exp. Psychol.* LIII, 1957, 89–93.

[4] Compare A. MICHOTTE, Perception et Cognition, *Proc. XIVth Int. Cong. Psychol.* (Montreal, 1954), North Holland Publ. Co., Amsterdam, 1955, 70–91.

sponses.[7] Secondly it enables the experimenter to be in full command of the experimental conditions; these, because of their simplicity, are completely under his control in such a way that he can combine them and vary them systematically as regards both quantity and quality exactly as he wishes.

Stage II. Systematic modifications in the stimulus-conditions introduced at this point in our research enabled us to establish the following two propositions: (i) that the frequency of responses having a causal signification varies gradually as a function of the changes introduced into the stimulus-conditions, it being possible for some of these conditions to be compelling at a level of virtually 100%; (ii) that alterations in the conditions bring about corresponding differences in the precise turns of phrase with which the causal responses are qualified.

The 'concomitant variation' which occurs in these two ways thus indicates an extremely close link between the causal character of the responses and the structure of visual stimulation.

During this second stage it is also possible to show that the occurrence or non-occurrence of a causal response is determined by the spatio-temporal relationships between the elements in the situation (viz. objects and movements), and depends on the way in which these are combined; other aspects, such as the shape, size, and colour of the objects, are of minor importance.

With this information it was possible to set up stimulus-conditions which evoked causal responses in cases where such responses were incompatible with the subject's acquired knowledge of mechanical laws. These are the paradoxical cases.[8] In addition it was possible to set up

[7] It should be noted in this connexion that causal responses on the part of subjects can also be influenced by earlier experiments made in similar schematic situations. It is therefore often desirable, and sometimes even indispensable, to work only with *new* (naïve) subjects, i.e. with subjects who have never taken part in experiments of this kind and who in addition are quite unaware of the object of the research in which they are taking part.

For the same reasons it is also often useful to carry out experiments in which each presentation is made in isolation and is followed immediately by a verbal report from the subject. These presentations can be repeated if it seems necessary (compare p. 33).

The disc method is readily adaptable to the use of this procedure. All that is needed is that the experimenter should control the rotation of the disc by means of an electro-magnetic clutch.

[8] It has been possible to study one of these paradoxical cases (exp. 54, p. 158) a little more closely during the course of fresh research on the Entraining Effect, in which we used the method of paired comparison.

This research has shown that the result, contrary to all expectation, was

Indeed, it is in this way that verbal reactions are used in all psychophysical experiments.

One need not stop here, however, since it is possible, even if we retain the same basic way of looking at things, to pass beyond this level and use the subjects' verbal responses in a more rewarding way, or at least attempt to do so. The information which they supply can lead the experimenter to think up new hypotheses with regard to the properties of the phenomena x, y, z; and these hypotheses can perhaps sometimes explain the use by subjects of particular expressions to refer to an event before them or an aspect of the situation presented to them.

When such hypotheses are formed, appropriate experimental situations can be set up so as to check their validity; hence we may ultimately arrive at the introduction of new distinctions, the formation of new concepts, and the formulation of new laws, all of which apply exclusively to the 'phenomenal world'. This is what has been achieved to a great extent by the psychologists of the Gestalt school and by many others who have followed them.

As examples of new distinctions may be cited the distinction between figure and ground, that between contour and enclosed space, and that between perspective and projective size; examples of new concepts are 'Gestalt' itself, 'centration', 'part-whole relations', 'absorption', 'internal hierarchy', and 'belonging'; examples of new laws are the laws of 'structural organisation', e.g. those relating to integration, segregation, spatial and temporal contiguity, similarity (in the form of 'common fate' and 'good continuation'), and many others.

It is from this general standpoint that all my work during the last twenty years has been undertaken.

To make the exposition of these ideas precise, I should like now to give an outline of the development of my research on perceived causality, with a brief indication of the logical and experimental stages through which the work has passed.

Stage I. During this stage I attempted to determine what were the simplest experimental conditions in which causal responses could be obtained.

These conditions can be extremely schematic, as is shown by exps. 1 and 2 (pp. 19–21). This has a double advantage; first it eliminates the influence of much acquired knowledge (acquired, that is, in connexion with our use of familiar objects or as a result of our habitual actions) which might sometimes be influential in producing causal re-

stimulation, such as could have been achieved by an electrical recording device.

On the other hand, if the contact was made to take less time, the subjects described what was happening in an entirely different way. They put the emphasis on the fact of an intimate intrinsic link between the two phases of the experiment, such that the events of the first phase exerted force or action on those of the second.

Now findings of this sort allow *a priori* of being interpreted in two different ways. This poses a problem for the experimenter.

Given that he cannot know what the subject sees and is aware only of the way in which the subject describes 'what is happening' in the slit of the apparatus, it is perfectly possible that the subject's response is the result of an interpretation of 'what he sees' rather than a simple description of it. Thus when the subject gives the verbal response 'A launches B' each time B starts to move immediately after A has come up to it, this may be because he has been influenced by everyday experience and his acquired knowledge of mechanics; in other words he *knows*, when he *sees* the movements in conditions analogous to those of our experiments, and where the movements follow one another immediately, that the movement of the projectile is brought about by the impact of the striking object. In that case the subject's response would be dictated not only by what he sees but by what he knows about what he sees!

There is another possibility, however. One can form the *hypothesis* that the reduction in the duration of the contact produces in the subject as a result an entirely different impression from that which occurs when the contact is prolonged. According to this hypothesis the verbal response is not an interpretation but has a descriptive value; it indicates that, for the subject, the way in which he sees the events taking place in the slit is specifically different in the two cases, viz. either two successive independent events or a single complex event; and this complex event can be expressed correctly, in the opinion of the subject, only by the use of words of causal significance.

Now it seems that there are good reasons for a decision in favour of the latter view.

1. There is the unanimous assertion of the subjects that what they see is altogether different when they speak of launching or entraining and when they mention a duality of independent movements. This constitutes at least a prima facie case in favour of this view. In this connexion it is interesting to note that on many occasions professional

experiments in such a way that stimulus-conditions which correspond to well-known cases of mechanical causality nevertheless fail to give rise to causal responses; these are the negative cases.

Up to this point there would be no practical difference in the interpretation of the results whether one adopted a strictly behaviourist point of view or a phenomenological one, since the responses merely indicate the presence or absence of events x differentiated by the subject. Moreover, it is clearly possible to develop research in the form of an examination of how the verbal and non-verbal behaviour of subjects is affected by experimental conditions analogous to our own but set up in different circumstances and in a different way.

Stage III. This development, however, can take place in a different direction and with different intentions; and it is here that by deliberately adopting the point of view of experimental phenomenology one can go beyond these first stages, and attempt to arrive at certain characteristic properties of the structure of events x. If successful, one is then in a position to define precisely the import of verbal responses in research such as ours.

At the start we should remember that a whole series of experiments, carried out as part of Stage II, have shown that to quantitative differences (e.g. duration of contact when the two objects come together) there correspond responses whose meanings are in some respects fundamentally opposed to one another. Thus in experiments on launching, for instance, if the duration of the contact exceeded a certain value, subjects said that one object started to move and went to a position beside the other, that it stopped there, and that the second object then started to move in its turn, doing so quite as spontaneously as the first and independently of it. This kind of response, of course, is nothing but a literal translation, or accurate reporting, of the retinal

more favourable to entraining if the motor object moved faster at the moment when it began to push the projectile than if it slowed down, even though the latter is the situation with which we are familiar from everyday experience and the laws of mechanics; and there was actually quite a large difference of degree. The causal impression was best of all when the initial speed was maintained during the two phases of the experiment. This also does not square well with the laws of mechanics, but is very easily understood on the theory which I shall set out later.

See on this subject, A. MICHOTTE, L. KNOPS, and A. COEN-GELDERS, Étude comparative de diverses situations expérimentales donnant lieu à des impressions causales d'entraînement, *Contributions à une psychologie humaine dédiées au Professeur Buytendijk*, Utrecht, Spectrum, 1957, p. 290.

provide an indication as to method, since they show that the character of the responses is determined primarily by the spatio-temporal combinations set up in the stimulus-systems. We are therefore justified in supposing that the differential characteristics of the phenomena x which interest us are themselves of a structural kind. Thus it is to a structural analysis that we must now turn our attention.

(ii) If we can solve this point satisfactorily, we shall next need to know what properties of these perceptual structures justify the use made by the subjects of causal responses.

(iii) Finally, all this will need to be completed by research into why it is that the experimental conditions of entraining and launching determine the formation of the specific structures in question.

These three problems put together make up the whole theory of the perception of mechanical causality; and I have therefore reserved a special section for them.

2. THEORY OF PERCEIVED MECHANICAL CAUSALITY

Since the time, some years back, when I first tried to formulate a theory which would make it possible to understand why in their responses subjects used expressions having a causal significance, our knowledge of the facts has increased in a remarkable way, particularly quite recently in research which will shortly be appearing in print. As a result I have been led to reconsider the whole problem, and the outcome has been a new theoretical conception much simpler than the old one (especially with regard to launching). Its development was indicated, albeit incompletely, in my article on phenomenal causality in *Studium Generale*.[10] Needless to say, some of the elements which play a part in this theory had already been used in the previous one and had been discussed extensively in connexion with it. Nevertheless I think it is desirable at this point to return to these particular issues in order to make the present exposition as complete and clear as possible.

(i) *The Distinction between Movement and Displacement*

Stage IV. Subjects who take part in experiments on entraining or launching are struck at the start by the contrast which they notice between the apparent origin of A's physical movement and the apparent

[10] A. MICHOTTE, La causalité phénoménale, *Studium Generale*, 10. Jahrg. Heft 6, 1957, p. 384.

psychologists who had read my book but who had never witnessed the experiments were quite astonished when these were presented to them during a visit to Louvain. They made a special point of saying that this was quite different from what they had imagined to themselves and that the difference leaped to the eye!

2. There are of course the negative and paradoxical cases, which give strong grounds for excluding the intervention of acquired knowledge.

3. The fact of concomitant variation is very difficult to square with a theory of interpretation based on experience and acquired knowledge. It is hard to see how a difference of a few hundredths of a second or of a few millimetres could make itself felt systematically in the responses, when in most cases where interpretation of visual shapes plays a part (e.g. the reading of the same words written by different people) the link between the meaning and the geometrical shape of the words is an extremely loose one.

4. To these must be added a consideration which in my view is decisive. It is that the specific structural organization of launching and entraining, as it would be expected to be in theory on the basis of experimental data obtained to date, is adequately expressed by the causal terms which the subjects use, as will be seen later.

From all this we may conclude, I think, in accordance with the hypothesis formulated above, that, in our particular experimental conditions, the phenomena x which adults (and children who are sufficiently far developed) describe in causal terms are *specifically different* from those which they do not describe in this way.

This is only a first step along the path of our phenomenological study (in the sense which I have given to the word). The position is still extremely vague, since all we know as a result is that causal responses arise when the phenomena are of a specific kind; and this would be of only limited interest if one went no farther. It has the merit, however, of giving rise to new problems which we can try to resolve by following the same principles.*

(i) In the first place we may wonder if it is possible to have a more precise knowledge of the phenomena in question and of the way in which they differ from those which evoke non-causal responses. For research into this point the developments mentioned under Stage II

* Compare A. MICHOTTE, Autobiography, in *A History of Psychology in Autobiography*, Clark University Press, IV, 1952, pp. 227 seq., and A. MICHOTTE, Autobiographie, *Psychologica Belgica*, Louvain, 1954, I, pp. 208 seq.

be produced by 'participation' in the movement of another with which it is linked structurally.[11]

In other words, according to our hypothesis, the 'movement'-character is a particular phenomenal property which does not necessarily appear in all supraliminal changes in position as they take place but only in some of them. It is therefore justifiable to assert that there is a valid distinction *on the phenomenal plane* between movement and change in position.

This hypothesis originated, as we saw, during experiments on entraining. Two points therefore require consideration, viz. how wide its general scope is, and how it applies to structures of a causal kind; and we shall have to consider from this twofold point of view whether its validity can be justified experimentally.

As far as the second point is concerned (i.e. the theory of causal impressions), this is discussed in the two following sections. I shall not therefore spend time on it here but shall limit myself to a consideration of the first point.

It should be noted at the start that various arguments in its favour have been set out earlier in this book (pp. 135 and 151). Further demonstrations on this subject were also given at the XVth International Congress of Psychology at Brussels in 1957.[12]

To complete matters we may call attention to an everyday observation which convincingly shows that movement and displacement are not necessarily identical from a phenomenal point of view. This observation relates to the perception of groups of objects moving simultaneously at the same speed and in parallel directions, although they need not necessarily belong all to one plane, since the group can be tridimensional.[13] In such a case subjects agree in saying that they see only one movement, not a group of movements, and that the movement

[11] This type of structure (including 'participation' in particular) does not play any part in the case of induced movements. These, when they occur, clearly belong to the objects, which, even though physically motionless, none the less seem to move.

[12] See A. MICHOTTE, Réflexions sur le rôle de langage, op. cit.

[13] A very simple way to produce these conditions is to project on to a screen images of holes pierced in a slide the rest of whose surface is opaque. It is possible to use seven or eight circular holes which can be of different colours and dimensions and set out irregularly. By pivoting the projector on its axis, a strict spatio-temporal parallelism is obtained between the movements performed by the circles on the screen; this is indispensable if they are to appear to move en bloc.

origin of B's physical movement. Whereas the starting off of A seems spontaneous, that of B seems to depend on the preceding events.

They soon see, however, that this is not all, and that these movements not only differ in their origin but also show quite different characters over some considerable part of their length (viz. the part which we have called the 'radius of action'). This difference, too, is what distinguishes in such a clear way the case of triggering, where the movements differ from those of entraining and launching only in their origin.

Now the characters belonging to the two movements are extremely difficult to express in words; and I was very much puzzled by this until I had examined a sufficient number of particularly explicit responses whose significance agreed with one another. Here are some examples from experiments on entraining: 'There is only one movement, A's movement; object B is quite inert.' 'B *is* in movement, but A *has* the movement.' 'B participates in A's movement, but has not itself any movement of its own.' 'It is A which does everything; B does nothing.'

Responses of this kind then suggested to me a new hypothesis according to which the physical movement of an object, although sufficiently rapid to be seen as a movement, could in certain conditions appear as a simple change in position, without this displacement taking on the perceptual (phenomenal) character of movement belonging to the object in question.

These terms 'movement' and 'displacement' have often been used by psychologists to distinguish direct perception of movement from indirect, in other words from the sort of movement which occurs when the speed is subliminal. This happens, for instance, in the case of the hour hand on a clock; we do not see its movement, but we see that it has changed position from one moment to the next. In the present case we are concerned with something different, as was implied above, since the speed of this displacement is supraliminal, and according to our hypothesis one can see a continuous change of position by an object without this change appearing as movement. (Compare pp. 135 seq. and pp. 151 seq.)

Such a possibility is of course excluded in the case of the supraliminal displacement of an *isolated* object, when there is always movement. It is different, however, when several objects which change position are integrated in certain ways in complex perceptual configurations. In that case the displacement of one of them can seem to

fact that we are concerned here, as I have already indicated, with changes of a purely spatial kind; their temporal aspect is given by the movement of the motor object in which the object entrained or launched participates (see p. 134).

Having discussed these preliminary points, we may now pass on to discussion of the theory of the Entraining and Launching Effects, and the part played in it by the 'movement'-'displacement' distinction.

(ii) *Theory of the Entraining Effect*

If we carry out the Type-experiment of entraining and lengthen the common course of the objects sufficiently, it is possible to distinguish three successive phases during the events which we observe.

In the first phase there are two objects, of which one moves in the direction of the other and joins it.

In the third phase the two objects are integrated in a total configuration (such as a bi-coloured rectangle), and it is that which moves.[15] Thus in view of the fact that there is no break in the movement and that it is continuous from the start of the experiment, we may say that there occurs a *substitution* of the object performing the movement; this takes

[15] It has been possible in our experiments to observe three different sorts of total configuration according to the nature of the objects and the spatial relationships between them.

In the simplest case the shapes of the objects are such that, when they are placed side by side, they go to make up a new shape, with a contour of its own resulting from the combination; this is the bi-coloured rectangle of the Type-experiment (see p. 21) or the uni-coloured rectangle of exp. 99 (see p. 331). Secondly, if objects A and B have shapes which do not lend themselves to combinations of this kind, or if they are themselves made up of groups of objects, the effect of the integration is to unite them in a total group comprising all of them. Thirdly, the experimental situation can be such that, at the moment when they join up, object B has become included in object A; and in that case the final configuration is that of the Transport Effect, object A constituting the vehicle and object B the transported object, which A has simply picked up and carried off (compare pp. 150 seq.). Analogous cases from ordinary life can easily be found. Thus a railway wagon in movement which meets another, hitches on to it, and pushes it along in front would be an example of the first situation; the second would occur if a group of objects sliding over an inclined plane carried along another which was lying in the way; and an example of the third would be the case of a spade going deep into the ground and lifting up a spadeful of earth.

Other configurations are also possible, but they have not been introduced into our research. I am thinking in particular of structures of a hierarchical kind where one part appears as an accessory belonging to the other, such as a sign or index figure accompanying a letter or numeral. Experiences of entraining could of course occur with material of this kind.

of the whole belongs to the group as such. Nevertheless each of the constituent objects travels along a path which is its own and different from that of the others. Their changes in position are therefore distinct from the movement of the whole which does not belong to any of them in particular but of which they are collectively co-performers. Consequently there is a real kinematic integration here[14]; and the same is true *a fortiori* each time an extended object composed of distinct parts is seen in movement.

The objection may perhaps be made that the movements of the different objects are only partial movements which fuse into a total movement. But this way of putting things contains a confusion; for even if there is a plurality of physical movements, this plurality is translated in the responses of the subjects as an overall movement, which from a perceptual point of view is a single one and does not appear at all to be 'composed' of a series of partial movements.

It should be mentioned here that on several occasions I have been asked why I did not use the term 'passive movement' rather than 'displacement'.

The reason for this is easy. The distinction in question between 'movement' and 'displacement' is a phenomenal one; consequently the use of the words 'active' and 'passive' would need to have a phenomenal meaning also. Now although the term 'passive movement' can be applied, even if rather loosely, to the displacement of object B in cases of entraining and launching, this is not so in other very closely related situations where the use of the 'movement'-'displacement' distinction is required. The case of group movement, for example, which I have just been considering, is typical of this, for since all the objects are co-performers of the spontaneous movement of the whole, they clearly have no character of passivity; and the same is true in the Transport Effect, as I pointed out earlier (p. 152).

These arguments are further reinforced if we consider that the notion of 'passive movement' in the phenomenal sphere is a questionable one, since from the phenomenal point of view movement always appears as to some extent a manifestation of activity (see p. 22–23).

Finally, the word 'displacement' seems to me fully justified by the

[14] The words 'kinematic integration' or 'integration of the movements' do not of course stand for a sort of 'mental chemistry', but simply indicate the fact that the multiple parallel movements of the stimulus-system appear to the subject as a *single* event, viz. a group movement (or possibly, in other cases, as transport, entraining, launching, etc.).

It is clear that the *displacements* of the two objects are phenomenally of a piece in all cases of entraining. This is plainly seen in the fact that the more similar the courses followed by the two objects after they have joined together the more marked does the character of entraining become, as will be seen later. In the limiting case the paths followed by the objects (or by their phenomenal centres of gravity—a point of considerable importance) *coincide completely*. This, however, is not an absolute necessity for the Entraining Effect to occur; there can be simple parallelism without contact (even, indeed, in the third dimension), although the structure is much less assured in this case.

To this spatial similarity is added similarity in point of time, or in other words similarity of speed, and sometimes similarity in the way in which speed of displacement varies. These are directly connected *qua displacements* even when the objects displaced remain distinct.

Here we have the special characteristic of the structure of entraining, for, since object A alone is the performer of the movement, while B is apparently inert, the unification of the two displacements must necessarily show itself in the fact that it is object A in movement which seems to 'displace in addition' object B, or conversely in the fact that object B appears to 'participate' in the movement of object A. If we wish to define in terms of structural organisation that to which these 'appearances' correspond, we must appeal to the concept of phenomenal duplication, since the single movement presents a double aspect—that of movement of object A and of displacement of object B (compare pp. 136 and passim). As we know, similar phenomena occur frequently in the sphere of perception. To quote one example of a very clear kind and very similar to the case of the Entraining Effect, we may mention again the Transport Effect, in which the transported object no longer has its own movement in the same direction as the vehicle, but simply participates in the vehicle's movement. There, too, the common displacement is seen at one and the same time as movement of the vehicle and as simple displacement of the transported object (compare pp. 150 seq.).

As we have shown already, however, this type of structure does not mark the Entraining Effect off completely from other phenomena, since the same structure is also found in situations which do not elicit causal responses, such as the Transport Effect. The latter involves a stabilised structure, a stationary state, while causal responses are related to a 'becoming' and are linked to the period of time during which the structure is being established (compare pp. 154 seq.)—in other

place during the second phase, which is decisive for causal responses. From a study of this second phase we should thus be able to understand the processes which have led to the substitution.

Stage V. Let us now suppose that the two objects have reached a position side by side, with one or other in front. The second phase begins when object B then starts to move at the same speed and in the same direction as object A. These conditions, which constitute an application of the principle of 'common fate', normally result, as we know, in bringing about an integration of the movements and of the objects, which in fact is achieved in the third phase.

This integration, however, does not take place instantaneously, as is shown by the analysis of the structure characteristic of the second phase—an analysis which constitutes the fifth stage of our research.

It should be emphasised that this stage is limited to an investigation of the properties of the perceptual structure which occurs at this moment; it is in no way concerned with the study of the conditions which determine its formation. It should also be said at the start that, in conformity with the principles set out above, the analysis upon which we are embarking is guided by the responses of the subjects and that it will retain its provisional character until later steps in the argument have confirmed its validity.

The first point to be indicated here is that kinematic integration occurs quickly at the start of the second phase; and in the circumstances this integration is so complete that subjects say that they perceive only a single movement. There is thus unity of movement in the same way as there was in the case of the group described above.

Here, however, there is the formation neither of a group nor of a hierarchised configuration in which B appears as an appendage or satellite of A. This is excluded since the subjects expressly affirm that the two objects remain distinct during the second phase and are not integrated into a single total shape until the third phase.

We are thus confronted with an apparent contradiction; and matters are further complicated if we bear in mind—again in the light of what the subjects say—that the single movement is that of object A.

Indeed the subjects often add spontaneously that B is inert, thus suggesting that the distinction between movement and displacement is here playing a part of the utmost importance; and it certainly seems that it is this which enables us to understand the kind of structure that is peculiar to the Entraining Effect.

A Note on Figs. 9–22
(*diagrammatic representations of experiments*)

The Arabic numerals on the left indicate in each case the order in which the stages of the experiment occur; by this means it is easy to understand what are the relative positions of the objects at each stage. The arrows placed below the objects show that they are moving at that moment in a particular direction. The position of the objects at the crucial moment of impact, however, is always represented without an arrow, even in cases where one or other of the two objects is in movement at that moment.

Two points should be noted in connexion with these figures: (*a*) Not all stages in an experiment are represented; in particular the positions of departure and arrival have been omitted, since the objects are then motionless or covered by a shutter. (*b*) The objects and the distances which separate them are not drawn to scale. The reason for this is to avoid making the diagrams too large. Accuracy in this respect is unimportant, since the sole purpose of the diagrams is to make the descriptions in the main text easier to follow; and as far as exact numerical values are concerned, all the requisite details in the case of my own experiments will be found in the main text, while in the case of the other experiments the necessary bibliographical references have been given.

A complete list of the experiments to which the figures refer is given on p. 370.

words to the moment when the pre-existing movement of an object appears to extend on to another, whose displacement it thus assures. It is this evolution which is crucial in the circumstances, and to which we have given the name 'ampliation of the movement' (see pp. 143 and 154).

It is helpful, I think, to stress this point on account of the misunderstandings which seem to have arisen among various writers with regard to this matter.

What is involved here is, in my opinion, a crucial point in the theory. It is precisely this phenomenal evolution, this apparent extension of A's movement, and the absorption of B's displacement by the movement of A at the moment when the identification of the displacements begins to show itself, which accounts for the initiating or productive aspect which we have always maintained to be the essential and characteristic trait of causality (compare pp. 223 seq.). It is this which finds expression in the phrases which subjects use such as 'A *takes* B with it', 'A *gathers* B up in flight', 'A *pushes* B forward', and so on (compare p. 21); all these turns of phrase imply an operation in process of being carried out.

To sum up, the structure of the Entraining Effect reduces to this: the segregation of the objects and the movement of object A during the first phase are maintained in their entirety during the second. When B starts moving (physically), however, its displacement appears intimately linked with that of A; and yet there is not a fusion because of the phenomenal duplication in virtue of which there seems to be only a single movement appearing under a dual aspect, viz. movement of A and at the same time displacement of B. Thus in the last resort it is A in movement which seems from then on to displace both objects at once.

The character of transition possessed by the second phase is clearly recognisable here in that the two objects, which were entirely strangers to one another during the first phase, now become functionally united, and this constitutes an event which prepares the way for their integration in the total configuration of the third phase.

Stage VI. The question now arises as to the extent to which the type of structure just analysed corresponds to the stimulus-system in an entraining experiment. Are we justified in concluding, on the basis of principles generally agreed or by analogy with other facts which are well established, that the stimulus-system in question can be regarded as determining the formation of this structure?

thus performs a to-and-fro movement. It is also possible, of course, to make the objects move in the same direction as did A. (For a diagrammatic representation see Fig. 10.)

In either case the Entraining Effect occurs in a spectacular fashion.[17] The conditions in the Type-experiment of entraining (p. 21) come very close to constituting complete identity; the paths are shared, except for a slight difference at each end corresponding to the size of the objects.

A less favourable case is that in which there is no contact between the objects, and where the paths are simply parallel, since here the spatial

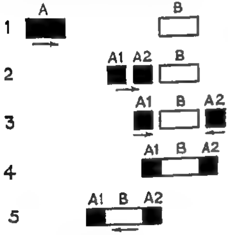


FIG. 10

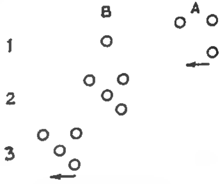


FIG. 11

identity is limited to the direction of the movements, and one finds that the structure of entraining becomes very much more unstable in these conditions.

Some very extensive research carried out by Thinès has made possible a demonstration of this. The research in question will shortly be published, and in what follows I have borrowed extensively from it.

As object A in his experiments Thinès used a group of three small circles of light, 0·9 mm. in diameter, arranged in the form of a right-angled triangle. The sides adjoining the right-angle, both 9 mm. long, were set vertically and horizontally. Object B was a similar circle which was made to appear in the middle of the hypotenuse of triangle A at the moment when A became level with it and B itself started to move. (For a diagrammatic representation see Fig. 11.)

[17] It should be noted that in both cases the common movement is a continuation of the movement started by one of the 'jaws' of the pliers, namely the 'jaw' whose movement was in the same direction as that of the common movement.

One of the salient features of the structure is clearly the kinematic integration which occurs at the second phase. What is involved here is, of course, an application of the principle of 'common fate'. As has been indicated above, however, there can be varying degrees of similarity operative here.

In optimal conditions there is complete identity as regards the orientation, direction, shape, and amplitude of the movements performed physically by the two objects (or, strictly, by their centres of gravity); and thus the unity which subjects mention in their responses corresponds exactly to the pattern of stimulation on the retina.

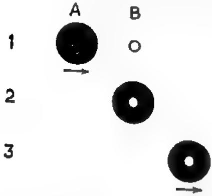


FIG. 9

This situation can be set up with no difficulty by the projection method. For example, one might project on a screen the images of two circles of which one, A, is larger than the other, B. A starts to move, travels in the direction of B, which is motionless, and slides behind it. At the moment when the two circles are completely concentric, B starts to move in its turn and they continue to move conjointly. (For a diagrammatic representation see Fig. 9. Also, for a similar experiment, see p. 153.)

Another experiment, of a very informative kind, was carried out at the time of our research on the perception of intentionality.[16] The disc method was used.

Exp. 96. Object A, a black rectangle, 10 by 5 mm., is motionless at a distance of 85 mm. to the left of B, a red rectangle of the same dimensions and also motionless. A starts to move at a speed of 5 cm. per sec. in the direction of B, and when it is 20 mm. off it divides into two small squares of 5 by 5 mm. The right-hand one moves at a speed of 10 cm. per sec., and goes beyond B until it reaches a distance of 5 mm. ahead of it, while the left-hand one goes during this time at A's original speed in such a way that it reaches a position 5 mm. behind B at the same time as the first reaches the position beyond B. The two squares then converge at a speed of 10 cm. per sec. towards object B, which they encircle like the jaws of a pair of pliers, and the three strips—red, black, red—then move together at a speed of 10 cm. per sec. in the opposite direction to that of the original movement of object A, which

[16] A. MICHOTTE, Autobiographie, op. cit., p. 210.

frequency for a common course of 7·3 mm. before the intervention of the blow dealt by C (this corresponded to a duration of 118 milliseconds at the speed used), and with 90% frequency for a common course of 15 mm. (corresponding to a duration of 242 milliseconds). These data are clearly valid only in the special conditions of this experiment. They show, nevertheless, like the previous findings, that the length of the common course and the corresponding duration necessary for kinematic integration to take effect are by no means negligible and in some circumstances can reach quite a considerable value.

However that may be, it is clear that this integration must always precede that of the objects if there is to be entraining or traction.

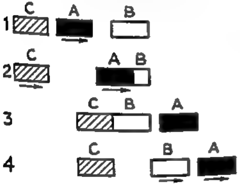


FIG. 12

FIG. 13

An objection may be made about the part played by 'common fate' in the curious case of 'amodal' entraining.

This occurs, it will be recalled, when object A completely covers object B after joining it, and then continues to move, without B being visible, until the time when it stops or disappears. (For a diagrammatic representation see Fig. 13.)

The stimulus-system does not in this case involve any common course, nor any visible movement of B, since B is motionless at the moment when it is covered by A and does not appear any more afterwards. Nevertheless subjects indicate that they can perfectly well see A entrain B in these circumstances, and Yéla has even been able to obtain evidence as to the length of the radius of action in such conditions.[20]

[20] M. YÉLA, La nature du 'rayon d'action' dans l'impression de causalité mécanique, *J. Psychol. Norm. Path.*, 1954, 47–51, p. 341.

In these conditions there was no immediate contact between the point B and the components of object A, and B was not placed at the exact location of A's centre of gravity during their common course. Thinès carried out this experiment on seventy-four new subjects, running the Type-experiment of entraining in parallel; and only 20% of the responses obtained were causal ones, as compared with 64% in the Type-experiment.[18]

Another question relating to the action of 'common fate' is that of the length of course necessary for the similarity to make its effects felt. Thinès has succeeded during his research in obtaining some precise information on this point. Operating in the conditions described above he has established that the length of common course required to produce the Entraining Effect increases with the speed of the movement, and that the corresponding duration in these experiments might have to be as much as 150 to 200 milliseconds if one was to be sure of at least 90% entraining responses. To achieve limitation of the common course B was made to disappear abruptly during its displacement while A continued to move.

Evidence on this point has also been obtained by Mlle Crabbé, our laboratory assistant.[19] Her experiments aimed at combining the experimental conditions of entraining—in this case the Traction Effect—with those of launching. It was so arranged that object A, in movement, passed in front of object B which was motionless, and that object B afterwards started to move in its turn when the distance between them had reached either 5 or 10 mm.; they then continued to move simultaneously in the same direction and at the same speed. It was possible, however, to bring in a third object, C, which also moved in the same direction and went to strike B at different times during the experiment, either at the particular instant when B started to move, or later, after it had followed a common course with A for a certain distance. (For a diagrammatic representation see Fig. 12.)

In these conditions the subjects gave either responses of launching or responses of traction according to the circumstances, and they were told that they must always say one or the other.

The results showed that 'traction' responses occurred with 50%

[18] G. THINÈS, *Contribution à la théorie de la causalité perceptive. Nouvelles recherches sur l'effet Entraînement*, Studia Psychologica, Publications Universitaires de Louvain, 1962.

[19] G. CRABBÉ, Rivalité entre différents types d'organisation structurale de causalité perceptive, *Causalité, Permanence, et Réalité Phénoménales*, op. cit., pp. 259–274.

frequency for a common course of 7·3 mm. before the intervention of the blow dealt by C (this corresponded to a duration of 118 milliseconds at the speed used), and with 90% frequency for a common course of 15 mm. (corresponding to a duration of 242 milliseconds). These data are clearly valid only in the special conditions of this experiment. They show, nevertheless, like the previous findings, that the length of the common course and the corresponding duration necessary for kinematic integration to take effect are by no means negligible and in some circumstances can reach quite a considerable value.

However that may be, it is clear that this integration must always precede that of the objects if there is to be entraining or traction.

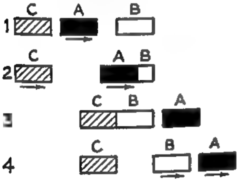
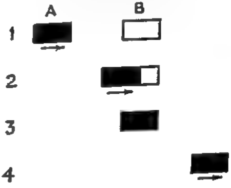


FIG. 12



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[20] M. YÉLA, La nature du 'rayon d'action' dans l'impression de causalité mécanique, *J. Psychol. Norm. Path.*, 1954, 47–51, p. 341.

This fits in with the idea of B's phenomenal permanence, in an amodal form, behind A—an amodal presence the result of which is that, where A appears, B seems to be present hidden behind A.[21] Thus since the amodal presence of B lasts for a certain time, B must clearly partake during this time in A's 'fate'. Thus the structure belonging to the Entraining Effect is present after all; it is only that the conditions of its occurrence are different here from what they are in the ordinary case, since they result indirectly from the structure of the Screen Effect.

As for the temporary maintenance of segregation between the objects and the resultant delay in their integration as compared with that of the movements, it should be noted at the start that these are clearly a consequence of the first phase of the experiment. If this is suppressed and the two objects start moving simultaneously, linked together, the twofold integration (of objects and movements) occurs simultaneously, and there is no longer any question of entraining, but there is the formation of one of the total configurations mentioned on page 317.

This being so, we need to examine closely the properties of the situation as it arises during this first phase.

The two objects are clearly distinguished and entirely separated by their intrinsic properties, i.e. their shapes and colours, and by their spatial position at a distance from each other. But to this must be added a crucial point—the difference between their 'states'. In the optimum case A alone is in movement while B is motionless, and from the kinematic point of view this establishes a hierarchy between them, the object in movement being dominant, phenomenally, in relation to a motionless object.

Now it is a remarkable point that these differences still prevail during the second phase, when on the one hand the movement continues to belong to object A, while on the other hand the inert character of object B is also maintained in view of the fact that it has no movement of its own.

It thus seems that we have here a manifestation of phenomenal permanence, during the short time of the second phase, of properties which characterised the objects during the first phase.[22]

[21] See in this connexion L. BURKE, The Tunnel Effect, *Quart. J. Exp. Psychol.*, 1952, 4, 121–138. Also A. MICHOTTE and L. BURKE, Une nouvelle énigme de la psychologie de la perception: le 'donné amodal' dans l'expérience sensorielle, *Proc. XIIIth Int. Cong. Psychol.*, Stockholm, 1951, 179–180.

[22] In what follows I shall use the term 'phenomenal permanence' (or simply 'permanence') in preference to 'persistence', 'perseveration', or 'after-effect',

amount the duration of stimulation required for the perception of a similar shape in a tachistoscope.

The responses given for lower values simply indicated that the two objects met in the centre, that they sometimes remained in contact for a moment, and that they then separated afresh. For durations of about 250 milliseconds it seemed that the departure occurred almost immediately after the meeting. This duration was a minimum, however, and was recorded with only one subject; for the others there was duality for a considerably longer time.

The principal interest of this experiment clearly consists in the fact that, according to what the subjects themselves said, there did not appear to be anything to justify their responses of duality at the second phase. It follows that these must have been due to some influence of the first phase, and to the maintenance of a type of structure which no longer corresponded to the stimulus-conditions occurring at the time.

By modifying the experiment it is possible to obtain further details in this connexion. The change consists simply in replacing one of the objects by an object of the same dimensions but red in colour. In these conditions there are again the same results as before, in that, when the duration of contact is short, the subjects indicate simple touching, while for longer times there may again be the formation of an overall structure, a bi-coloured rectangle, or, as one observer imaginatively put it, a 'small flag'.

The responses given by the subjects are extremely interesting in this case because they make it easy to discover in what respect the structures which occur as a function of the duration of the contact are different from each other.

When the duration is fairly short, the separation between the two adjacent objects occurs at the place where two surfaces, each with its own contour, are side by side; one could therefore say that the boundaries of the two objects are conjoined over this distance.

When the unitary configuration is formed, on the other hand, and the subjects say that they see a single bi-coloured rectangle, it is clear that this rectangle has a contour of its own, a continuous one, which at one and the same time includes the two red and black areas, and that at the point of their separation there is no longer a simple juxtaposition of two objects. On the contrary, this line has become from then on an interior detail, a dividing limit between the constitutive parts of a single object, viz. the total figure.

The permanence of the objects thus appears linked to that of their contours, and this certainly clarifies to some extent the nature of the processes operating during the passage from the second phase of the experiment (when the two objects are joined together) to the third (where there is a total configuration). It is therefore appropriate, I think, to link this fact with other similar ones which have already been investigated on the rôle of contour and its permanence.[23]

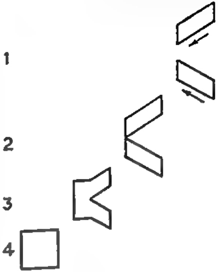

FIG. 15

Besides the permanence in the segregation of the objects, which has just been demonstrated, there is also in other cases permanence of the movements performed by these objects. This is confirmed in the case of the following experiment. (For a diagrammatic representation see Fig. 15.)

Exp. 98. (Projection method.) The subjects are presented with two small parallelograms, 6 by 12 mm., leaning in opposite directions at an angle of 30° to the horizontal, and projected vertically one above the other at a distance of 10 cm. on a broad background 1 metre square. These parallelograms start to move simultaneously with convergent paths forming an angle of 60°, and cover a distance of 10 cm. at a speed of 12 cm. per sec. before coming together. When they join up they change shape and orientation in such a way that, side by side, they constitute a square 12 by 12 mm. which then moves along a horizontal path whose direction corresponds to the line bisecting the angle formed by their paths when they moved obliquely. This movement is carried out at a speed of 9 cm. per sec., and after a distance of 30 to 35 mm. the square disappears behind a shutter.[24] The observation-distance was 1·5 metres, and no instructions were given about fixation.

Twenty-two subjects took part in this experiment, of whom ten were familiar with observations of this sort, while for the twelve others, who were students of philosophy, it was something quite new. Now except in one case where the response was ambiguous, they all declared that they saw the objects join up and then go off together one above the other.

The majority (sixteen out of twenty-two) indicated further that they saw a horizontal separation between the two objects after they had joined together; and one of the experienced subjects was actually so convinced of the physical existence of this separation that he thought that there had been a technical fault in the apparatus; and we had to present to him the horizontal course only, with the first phase suppressed, to convince him that at this moment there was only a single square of uniform colour which was moving on the screen. In fact it is very probable that a number of peripheral factors, connected with the way in which the retinal stimulation evolves, contribute to the formation of this separation. In view of the results of the preceding experiments, however, this is secondary from our point of view. What is important is that the subjects again say that they see a duality of shapes at a moment when the objects are already joined together and when the stimulus-conditions operating at that instant are such that, if there had not been the first phase, they would have seen *a square shape of uniform colour*.

Now it is a remarkable fact that the square shape was mentioned by only five subjects out of the twenty-two! Several of these expressly added either that there were two objects forming a single block, or that, as they continued one above the other, they remained separate for a short time and then became a single square.

For some subjects the segregation is complete. Thus a foreign subject, in his desire to show clearly what he saw, drew very accurately the two objects in their respective positions in the first phase, with an indication of their paths, but he still represented them in the second as two parallelograms linked together! When I myself was subject, I saw, after they had joined up, two rectangles linked together but slightly offset horizontally in relation to each other.

stencil, from behind, at the end forming the base of the angle. The result of this is to cause the images of the two parallelograms (corresponding to the intersections of the line of light with the oblique slits) to appear on the ground glass. Next the projector is made to pivot around its vertical axis in such a way that the line of light slides along the stencil and the images of the parallelograms then move along paths determined by the shape of the cut. The luminance of the parallelograms and the square was about 15·5 candles per sq. metre, and that of the background 1·7 candles per sq. metre.

It seems once more that the duration during which duality is maintained varies with different subjects, and that the length of course which we adopted, corresponding to a duration of about 300 milliseconds, was perhaps a little too long for some of them.

The conclusion to be drawn from this experiment is that there occurs a permanence not only of shapes but also of movements, and that kinematic common fate is not sufficient, any more than uniformity of colour, to ensure the immediate integration either of the objects or of their movements.

The experiments which have just been described, and many others along the same lines, show in a clear way the existence of a tendency *towards permanence of the characteristics of the first phase: the contours of the objects, and their movements as well, are maintained during the second phase, despite the modifications in the stimulus-conditions which mark its beginning.*[25] As has been indicated above, this tendency *is certainly one of the determining elements which go to make up the structure of entraining.*

Before we discuss this matter further, however, it may be of interest to supply a direct proof that permanence plays a part when the structure of entraining is formed. It was to establish this point that the following experiment was carried out.

Exp. 99. (Disc method.) Two similar objects, black rectangles of 5 by 8 mm., are present in the slit at a distance of 30 mm. from each other. At a given moment the left-hand object, A, starts to move towards the right at a speed of 5 cm. per sec. When it joins the other object, B, B starts to move in its turn at the same speed and in the same direction in such a way that from then on there is only a single black rectangle, 5 by 16 mm., in movement After travelling for 20 mm. it disappears behind a shutter. (For a diagrammatic representation see Fig. 16.)

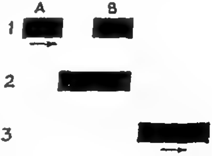

FIG. 16

in spite of the fact that the long rectangle is uniform in colour, the majority of the subjects see object A entrain B during its course,[26] the two objects remaining phenomenally distinct until the moment when they disappear. Moreover this distinction is confirmed even in the case of most of those who did not mention any causal impression; there were thirteen of these, out of a total of fifty-three subjects, and only two of the thirteen indicated the formation of a rectangle. Thus it is clear that there is duality of objects during the course of the Entraining Effect, but from the time when one passes beyond the limits of the radius of action one sees only the lengthened rectangle.

If we now consider the last three experiments taken together, we may say that all of them without exception bring about conflicting situations. Everywhere, in fact, the tendency towards permanence is in opposition to 'common fate'.

In exp. 97 it was the permanence of the contours which was opposed both to the forming of a combined contour in the total configuration and to the unity of the object.[27]

In exp. 98 there is a second conflict in addition to the one mentioned above, that between the duality of the movements and the formation of a single movement belonging to a total configuration.

In exp. 99 and in the case of ordinary entraining, a fresh complication arises which makes the conflict even more acute, since the difference between the 'states' of the objects in the first phase (i.e. one moving, one static) further reinforces the opposition to their being unified, and to the movements being unified also.

Now in all these experiments the same effect from the conflict is seen, viz. a *delay* in the establishment of the total configuration in relation to the beginning of the 'common fate'. This delay is clearly prolonged for as long a time as the tendency towards permanence remains the more powerful one; and it lasts until this tendency gradually loses its force and 'common fate', whose opposite effect is progressively more influential, finally becomes dominant.

In the case of exps. 97 and 98 the conflict is resolved simply by the passage of time; this is the only factor operative, because the states of the two objects (movement or rest) were the same during the first phase, and

[26] This was so for all the experienced subjects (eight out of eight) and for thirty new subjects out of a total of forty-five.

[27] The words 'unity of the object', of course, cover also the unity of the group, just as 'unity of the movement' indicates that the movement belongs to the combined configuration whether it comprises one unit or a collection.

they thus had the same 'past history' at the start of the second phase.

In the case of the Entraining Effect, however, it is entirely different. When the common course of the two objects begins they are by no means on an equal *footing*, since their 'past history' from the kinematic point of view is quite different. In the Type-experiment of entraining object A was moving while B was motionless and also inert. (The two are not the same thing, as we saw on p. 314.) *There is in this respect a contrast between the properties of the two objects*; and a contrast, or a disequilibrium, of the same kind occurs every time that there is entraining.[28]

The experimental conditions thus create in this case a supplementary conflict—a conflict between (*a*) the tendency towards maintaining during the second phase the kinematic disequilibrium existing at its start, and (*b*) the equality in unity which 'common fate' tends to bring about. To put the matter more concretely, we may say that there is a tendency to maintain an opposition between the states of movement of the two objects, even though in fact their displacements are identical, or all but identical, from the spatio-temporal point of view.

Now, as we know, *the influence of conflict on perceptual structures* varies considerably, both according to the nature of the conflict and according to the attitude and preparatory 'set' of the subjects.[29]

We have just seen that, in the simplest cases, the conflict can be resolved by extinction. In other conditions the consequences are more serious or more complex.

Sometimes there is an inhibition, and the resultant impression is chaotic. Or again, conversely, one of the tendencies can momentarily be so powerful *that a particular impression is forced upon the subject*. Moreover it often happens that different structures occur alternately.

In other circumstances, when the opposition *is only partial*, a compromise structure occurs, in which the evidence of conflicting influences is still found. It is in this category that the structure of the Entraining Effect belongs.

which passes from being a pairing-up to being an identification—becomes established and makes the displacements of the two objects all of a piece.

This reconciliation of opposed tendencies, however, is made *possible* only because of the phenomenal dissociation between movement and displacement, and it *actually occurs* because of the process of phenomenal duplication.

We are thus in a position to understand the whole mechanism by which this hybrid structure of entraining is formed; and it is clear that, if we take into account certain characteristics of perceptual organisation, it is to be expected that the stimulus-conditions which combine together in entraining experiments should be such as to produce this structure.

It may perhaps be helpful to emphasise the fact that the solution of conflicts, in the form of a phenomenal duplication, is frequently to be found in the perceptual sphere, not only in the case of vision but also in the case of hearing and the tactile-kinaesthetic senses, and in static situations as well as kinematic ones.

This is what also happens in the case of the Transport Effect, to which we have already referred.

Here, since the transported object is inside the vehicle or placed on top of it, it is the vehicle which normally constitutes its frame of reference.

Now, according to the laws governing perception of movement, the object inside can give the impression of moving with a movement of its own only if it moves in relation to its own frame of reference. In the case of the Transport Effect, however, the transported object does not change its position in relation to the vehicle, at any rate as far as the vehicle's advance is concerned; it thus cannot give the impression of moving in this direction. Yet we clearly see it change its position at the same time as the vehicle. Here, too, there is thus an apparent contradiction, and this becomes resolved, once again, in the fact that the object seems to 'participate' in the movement of the vehicle. In other words, the advance appears at the same time both as a movement belonging to the vehicle and as a simple displacement of the transported object (compare pp. 150 seq.).

Here is another example, borrowed from the sphere of static perceptions. This is the case, familiar to all those who have been concerned with problems of perceptual Gestalten, of linear figures whose contours have a part in common, as for instance in Fig. 17.

Here, too, there is a conflict, since, on the one hand, in virtue of the laws of perceptual organisation, each of the two shapes, the triangle and the square, should have its *own continuous contour*, and this would bring about a complete segregation of the two contours, while, on the other hand, a part of these contours is common to each. In these conditions one could legitimately suppose that one of the figures would appear as complete, while the other remained with an open part. This, however, does not occur spontaneously, or at any rate not often. Observers in fact see both figures complete; their contours are continuous and neither of them presents any lacuna. Clearly this can happen only if the common part is duplicated in some way. One possibility, for example, might be the occurrence of an illusion of localisation in the third dimension; thus the base of the triangle might seem, for example, to be in front of the top side of the square. To show that this structure did not in fact occur, I had a reproduction made of the figure in wire of 1 mm. diameter. Although this makes the impression of unity in the shared part overwhelming, the two figures nevertheless continue to appear complete. Here, as in the case of entraining, it is a matter of a duality of *aspects*; a line or part of a line which is perceived as being simple and as one belongs to two different contours; it thus fulfils different functions simultaneously and presents two distinct appearances.[30]

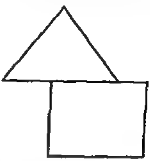

FIG. 17

In the Type-experiment of entraining, the structure of the first phase, which tends to be maintained during the second, comprises the presence of two objects, one in movement and the other at rest; but there is experimental evidence that the Entraining Effect can also occur in other conditions. These must now be considered, so that we may see if our theory is still applicable in such cases.

I had supposed that the presence of object B during the first phase was indispensable to maintaining the segregation of the objects during the second.[31] Thinès has shown, however, that this is not strictly cor-

[30] This figure, like all complex forms, is ambiguous in that it can be structured in different ways according to the attitude of the subject, or his 'set'; it is also possible to see one of the figures as complete and the other as open, or again it is possible to see a total figure of asymmetrical shape. The latter, however, does not arise spontaneously.

[31] See A. MICHOTTE, La causalité phénoménale, *Studium Generale*, p. 326.

rect. His experiments have certainly confirmed that the previous presence of B, motionless, is extremely favourable to establishing the structure of the Entraining Effect, but they also show that this can also be formed in other conditions. In particular he has carried out experiments in which B was absent from the visual field at the start, and suddenly appeared in movement, at a fixation-point marked by two arrows, at the moment when A was passing the same place. Causal responses have certainly been recorded in these conditions, although they occur less frequently than in the case of the ordinary experiment.[32]

However that may be, it seems as a result that the permanence of the state of movement of object A on its own can suffice to create the conflict situation occurring in the second phase. This makes good sense, since it is clearly contradictory that (*a*) the exclusive belonging of the movement to object A should be maintained, and (*b*) a common movement should belong to this total configuration which 'common fate' tends to bring about.

None the less it seems that the existence of a movement on the part of object A—or at any rate an apparent one—before the two objects join together and undergo a common displacement is absolutely necessary if the structure of entraining is to occur. It is hard to see how a conflict of a kinematic kind could occur in other conditions.[33]

Another modification of the Type-experiment of entraining consists in making object B move during the first phase, though more

[32] See G. THINÈS, op. cit.

[33] Tognazzo, during his interesting research on traction and entraining, has carried out a series of experiments whose results seem to be in conflict with our view that the priority of the motor object's movement in relation to the common movement is an absolute necessity. See D. P. TOGNAZZO, Contributo all' analisi degli effetti causali 'entraînement' e 'traction', *Memorie della Accademia Patavina, Classe di Scienze Matematiche e Naturali*, LXXI, Padua, 1959, 3–17.

In these experiments an object made an outward and return movement; at the end of the outward journey it met another motionless object, which then accompanied it during the return phase.

In these conditions the majority of the responses mentioned a 'traction', which is normal; but among the forty subjects taking part in the experiment there were fifteen who in some instance indicated an entraining. For each variation of the experiment, too, somewhere between four and seven subjects out of forty gave causal responses.

This result is clearly very strange. It should be pointed out, however, that this type of response depends, once again, on *the existence of a first phase in the experiment, preceding the common course*. Hence various hypotheses are possible. In the first place it often happens in our experiments that subjects have reported the presence of induced movements at the moment when the moving object approached a motionless object, the motionless object seeming to go to meet it.

slowly than A, in such a way that A joins B during its course; after this both move, one beside the other, at the same speed and in the same direction.[34]

The results of this kind of experiment depend, *ceteris paribus*, on the difference in speeds. When this is very small, one is approximating to the conditions of exp. 98 (p. 329), and the duality of the movements is maintained during the second phase. When the difference is considerable, on the other hand, the structure of the Entraining Effect becomes established, and the impact introduces a real cleavage between the 'active' movement of B in the first phase and its 'passive' displacement in the second.

This case, like the preceding one, is very instructive and requires to be taken seriously. It shows that in the Type case of the Entraining Effect it is not only the 'states' of the isolated objects (i.e. A moving, B motionless) which tend to be maintained because of the tendency to permanence, but rather the contrast between these states, as we have indicated above (p. 333). It is thus the opposition existing at the start of the common displacement which counts. This appears very clearly here. In effect it is the difference between the speeds of the movements in the first phase which tends to be conserved, although from then on the displacements of the two objects have the same speed. Hence arises the conflict; hence also comes its resolution, in which the displacement

The occurrence is so striking that two investigations have been devoted to it in our own laboratory, one of them forming part of the collection of research by Thinès mentioned earlier. It seems extremely probable that similar movements also occurred in Tognazzo's experiments, at any rate in a number of cases; and this would then fully explain the subjects' responses, since the motor object would already have appeared in movement in the direction of the common course before being joined by the other object.

According to another hypothesis there occurs at the moment of contact a triggering off of the movement of the object which had been motionless, and this ensures its apparent priority.

Lastly, one cannot exclude *a priori* the possibility that the serial order of presentation had some effect and that the subjects used expressions which did not adequately reflect what they saw. (On this point see next paragraph.)

In any case, in the absence of more complete data, it is impossible to reach a valid conclusion as to the significance of these experiments. To be convincing they should, in my opinion, have been carried out on subjects who were new to the task but familiar with scientific observation; also they should have been performed in isolation, i.e. not forming part of a series in which other causal situations were presented, and in addition one would need to be quite sure what exactly a subject meant by some particular response.

[34] Compare pp. 149-150. Also A. MICHOTTE, L. KNOPS, and A. COEN-GELDERS, Etude Comparative, op. cit., pp. 288 seq.

the result of an 'ejection' of B by an unknown cause from the 'gun' formed by the opaque rectangle; but this ejection had nothing to do with A's movement. In any case, whenever phenomena of this sort occurred, the operation of 'common fate' was held in check, and there was no longer any mention of entraining. As for the other responses, they, too, were non-causal, but were of the 'lighting-up' or 'pre-integration' kind which I shall discuss in a moment.

In another version of this experiment, again carried out by Thinès, the situation was simplified (see Fig. 19). Object A, a circle 27 mm. in diameter, moved towards a fixation-point marked by two arrows, and at the moment when it arrived there, another smaller circle, 10 mm. in diameter, suddenly appeared next to the other on the side to which it was moving (in a position corresponding to that of object B in the case of the Entraining Effect). This second circle had seven times more luminance than the first (74·5 candles per sq. metre against 10·5), and, in view of the amount of its luminance and its surface, its appearance would be expected to give rise to marked gamma movements. In these conditions none of the fifteen new subjects who took part in the experiment mentioned entraining; the movements were independent for all of them.

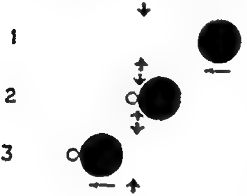

FIG. 19

(ii) I myself have performed a further experiment the result of which is similar. It was carried out by the disc method, and involved the use of the Screen Effect. (For a diagrammatic representation see Fig. 20a.)

slowly than A, in such a way that A joins B during its course; after this both move, one beside the other, at the same speed and in the same direction.[34]

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[34] Compare pp. 149–150. Also A. MICHOTTE, L. KNOPS, and A. COEN-GELDERS, Etude Comparative, op. cit., pp. 288 seq.

of B loses its 'movement' aspect and the duplication occurs which is characteristic of the structure of entraining.

Thus it is in fact the dominant character of the kinematic *structure* existing at the start of the second phase which tends to be maintained. This happens despite the partial alteration of the stimulus-conditions, and it is this which is the source of the conflict.

So much for our answer to the question raised at the beginning of Stage VI.

From all that has gone before we may draw the following conclusions:

1. The experimental conditions in which the Entraining Effect occurs—in other words the stimulus-system operative in the first phase and the change which it undergoes at the start of the second—give rise to a conflict situation.

2. The phenomenal duplication, as a result of which the conflict is resolved by a compromise, is a process (a psychophysiological one) which we come across in very diverse forms; it is one which occurs when the stimulus-system would be expected according to the laws of perception to give rise simultaneously to structures which are different yet partially compatible.

Before I pass on to a description of the next stage there is one point which I should like to emphasise. It is this. In the light of the facts described in this section, the concept of 'radius of action' takes on a far more precise significance than formerly. The first definition of this concept, it will be remembered, was 'the *distance* over which object B seemed to be entrained by object A'. Yéla, however, has shown that very probably what is involved is the spatial manifestation of a temporal determinant.[35] This view is clearly confirmed by our new experiments, since we may conclude from them that the radius of action is in the last analysis the duration through which the tendency towards phenomenal permanence displays its effects and thus determines the spatial and temporal length of the second phase of the experiment.

Stage VII. There remains a final experimental stage to complete, that of counterchecking; this is necessary for making sure that our analysis is a valid one.

If we take as our starting-point the idea that the structure of the Entraining Effect is formed as a result of the perceptual conflict occurring when 'common fate' starts to intervene, the validity of this idea can be checked by operating systematically on the factors responsible

[35] M. YÉLA, La nature du rayon d'action, op. cit., pp. 344 seq.

for the conflict. The check can be made in two ways, either (*a*) by ensuring the supremacy of the factors which favour the segregation of the movements, or (*b*), conversely, by reinforcing the factors whose action gives rise to their integration. In both cases one would expect a decrease in the number of causal responses.

(*a*) The first method was applied in three experiments. (i) In one of these, carried out by Thinès, the procedure was as follows. Object A consisted of three circles of light just as it did in the experiment described on p. 323. In this case, however, the circles were considerably larger in size, viz. 22 mm. in diameter, and the distances between them were larger also. At the start of the experiment the circles forming object A enclosed the extreme right of an opaque rectangle placed against the ground glass (see Fig. 18), and when they were set in movement they slid towards the left along the length of the rectangle. Object B was a similar circle, whose image was projected at the left of the rectangle; this was the point fixated by the subjects. When combination A became level with B and B began to move, B was situated in the middle of the hypotenuse of triangle A, and it stayed in this position throughout the whole length of the common course which followed. These experimental conditions were, of course, favourable for the Entraining Effect. It was quite different, however, if the image of B was projected at the moment when A reached, or was about to reach, the extreme left of the rectangle; the responses obtained in these conditions, even though they were of many different types, were non-causal without exception.

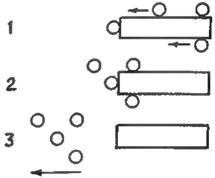

FIG. 18

The majority of subjects asserted that the movements of the two objects were quite independent of one another; and this seemed to be linked with the fact that B's appearance was practically instantaneous and was often accompanied, because of its dimensions, by fairly pronounced gamma movements. Thus when B came into view at the moment when A was passing it, its final displacement appeared as a continuation of the gamma movements of expansion; and as a result of this it took on the character of being a movement belonging to object B. A number of subjects sometimes added that the movement of B was

the result of an 'ejection' of B by an unknown cause from the 'gun' formed by the opaque rectangle; but this ejection had nothing to do with A's movement. In any case, whenever phenomena of this sort occurred, the operation of 'common fate' was held in check, and there was no longer any mention of entraining. As for the other responses, they, too, were non-causal, but were of the 'lighting-up' or 'pre-integration' kind which I shall discuss in a moment.

In another version of this experiment, again carried out by Thinès, the situation was simplified (see Fig. 19). Object A, a circle 27 mm. in diameter, moved towards a fixation-point marked by two arrows, and at the moment when it arrived there, another smaller circle, 10 mm. in diameter, suddenly appeared next to the other on the side to which it was moving (in a position corresponding to that of object B in the case of the Entraining Effect). This second circle had seven times more luminance than the first (74·5 candles per sq. metre against 10·5), and, in view of the amount of its luminance and its surface, its appearance would be expected to give rise to marked gamma movements. In these conditions none of the fifteen new subjects who took part in the experiment mentioned entraining; the movements were independent for all of them.

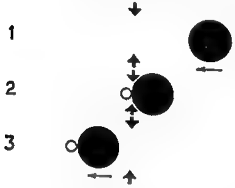

FIG. 19

(ii) I myself have performed a further experiment the result of which is similar. It was carried out by the disc method, and involved the use of the Screen Effect. (For a diagrammatic representation see Fig. 20a.)

Exp. 100. Object A, a black rectangle, 5 by 8 mm., positioned in the slit at the left, moves towards the right at a speed of 4·3 cm. per sec. After it has travelled for 40 mm. without any alteration in its course, there appears at its front (i.e. right-hand) end a red strip which becomes progressively larger at a speed of 5·6 cm. per sec. until its length reaches 5 mm. This is object B. Next the black rectangle and the red square positioned in front of it move without interruption at a speed of 4·3 cm. per sec. over a distance of 20 mm. before disappearing behind a shutter. The observation-distance was 50 or 60 cm., and the subjects were asked to follow A with their eyes.

A variation of the experiment (see Fig. 20b) consists in making the

red strip appear at the rear (left) end of object A; it then becomes progressively larger at a speed of 3·1 cm. per sec. (slower than that of A) until it reaches a length of 5 mm.; the whole then continues to move at a speed of 4·3 cm. per sec., B this time being positioned behind A.

Fifteen new subjects took part in the first version of the experiment and seventeen in the second. All gave similar responses, to the effect that they saw the red square *emerge spontaneously* from behind the black

Fig. 20(*a*)

Fig. 20(*b*)

rectangle either ahead of it or to the rear of it, and that the objects continued to move together, but that there was no question of B being entrained by A.[38] The fact that this spontaneous emerging-movement of B's is seen at the moment when 'common fate' begins is thus proved to be sufficient to ensure the momentary autonomy of the object's later movement. Moreover the fact that the emerging-movement is spontaneous is the operative factor here; it is not the speed, since in one case it is greater than that of A while in the other it is smaller. Again, in view of the way in which B appears progressively, there is no longer any question of gamma movements occurring here.

(iii) A third experiment, based on an entirely different principle, also succeeded in offsetting the influence of 'common fate' on the integration of A's and B's displacements. This experiment, which was carried out by Mlle Crabbé, using the disc method, has already been

[38] In the first version of the experiment one subject indicated that he saw B pull A behind it, which obviously shows that for this subject there was a clear dominance of B over A; this is understandable in view of its greater speed at the moment of its appearance. Also there is no difficulty in modifying the conditions of this experiment in such a way as to impose the structure of the Traction Effect. All that is necessary is to make the speed of B's 'exit' very much quicker than that of the progress of A in the first phase (6·5 cm. per sec. as compared with 1·2 cm. per sec.), and then to make the two objects travel at the higher speed.

described on p. 324; and as we saw, conditions can be so arranged that object B is already integrated, in a structure of launching, with a third object, C, at the moment when the common course of A and B begins (see Fig. 12, p. 325).

In this case, for experimental reasons which can readily be understood, the common course of A and B had to be brought about in the form of a traction experiment (compare p. 160). In a pilot study, object A, moving from left to right, joined B and passed beyond it; and when it was 5 mm. away B began to move in its turn in the same direction and at the same speed. The influence of 'common fate' is clearly shown in the results; and in spite of the lack of contact between the objects, 58% of the forty new subjects taking part in the experiment indicated that, after overtaking it, object A drew B along behind it.

The experiment was then modified as follows. The third object, C, was made to play a part; it came rapidly from the left and dealt a blow to object B at the very moment when B was beginning to move behind A.

This fresh experiment was given to forty more new subjects from the same student population as the previous group, and this time not a single one mentioned the Traction Effect. 82%, on the other hand, indicated that C launched B, and that A's movement had nothing to do with this operation, occurring at a moment when A was beyond B; and the others simply mentioned three successive movements, independent of each other.[37]

These three examples thus show that it is possible to make causal responses of entraining disappear while still maintaining the common course of objects A and B during the second phase, provided we prevent their displacements from being integrated.

(*b*) As for the second method of suppressing the conflict which gives rise to the formation of the structure of entraining, it is the converse of the first, and consists in favouring the action of 'common fate' by opposing the segregative action of the first phase.

We have seen already (p. 336) that segregation can be weakened by suppressing B's presence before the impact. One can go farther in this direction, however, and reach the stage where it is eliminated completely; this is done by making use of the Screen Effect, as was done in the following experiment, which we have often used as a demonstration.

A group of circles of light of different sizes, ranging from 2 to 3 or 4 cm. in diameter and irregularly arranged, are projected on to a pane

[37] G. CRABBÉ, op. cit.

of ground glass. They all move at the same speed and constitute object A (compare p. 315, above). At a given moment a new circle, B, gradually appears in the group, its front edge (from the point of view of the direction of A's movement) coming into view first, and the rest following at the same speed as the progress of the whole.[38]

In these conditions it is possible to create the compelling impression that the object which is seen to appear *pre-existed* in the group, and that it was already moving with it during the first phase, although hidden.[39] Thus there is no longer any question of entraining, since (*a*) the apparent pre-integration suppresses segregation during the first phase, and (*b*) when object B appears we are straight away in the presence of the total configuration of the third phase, without this needing to have been prepared for by the second.[40]

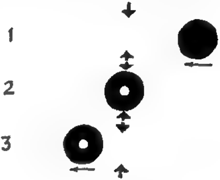

FIG. 21

Finally I shall mention a last experiment in which we introduced conditions of figural integration, so as to hold in check the segregative influence of the first phase and reinforce the action of 'common fate' in the second. (For a diagrammatic representation see Fig. 21.)

Exp. 101. Object A was a circle of light 27 mm. in diameter, with a luminance of 10·5 candles per sq. metre, projected on a screen of ground glass at a distance of 85 mm. from a fixation-point marked by two vertical arrows, with their tips 34 mm. apart. The luminance of the screen was 1·3 candles per sq. metre. The object started to move and travelled towards the fixation-point at a speed of 9 cm. per sec. When it arrived there, a small circle of light, 10 mm. in diameter, B, was projected instantaneously on to the centre of A. The figure shown consisted from then on of a central bright circle with a luminance of

[38] To carry out this experiment, it is necessary to put a screen between the projector and the pane of ground glass. (It should be at a distance such that the subjects cannot see it, so as to avoid the possible occurrence of the 'gun' effect mentioned earlier.) The image of the object which we want to cause to appear in movement during the displacement of the whole is intercepted by the screen during part of its course.

[39] The same thing has been observed by Thinès on various occasions during his research.

[40] To pass from this experience to a clear-cut Entraining Effect, all that is necessary is that B should be projected in advance, motionless, to the place where it appears, and that it should start to move at the moment when A passes over it. Compare p. 153.

74·5 candles per sq. metre, surrounded by a concentric ring which is less bright. This figure continued to move, without interruption, at the original speed of A. The observation-distance was about 2 metres.

It will be seen that what is involved here is the formation of a regular configuration, which could be expected straight away to bring about an integration of objects A and B at the moment when 'common fate' began to operate, once more suppressing all possibility of conflict.

The experiment was given to seventeen new subjects. None of them indicated any causal influence of any kind. Their responses were almost stereotyped, and mentioned either the 'appearance' or the sudden 'lighting up' of a light in the middle of object A—a response again resembling those which were given in more or less similar conditions by Thinès' subjects.

The results of the control experiments fit completely, as far as one can tell, both with those in which we analysed the structure of entraining and with those in which we studied the conditions of its formaticn. In addition our view will receive further confirmation when we set out our theory of the Launching Effect, which is our next task.

(iii) *Theory of the Launching Effect*

The theory of the Launching Effect which we formulated earlier (pp. 128 seq.) can be applied only with some difficulty to our present data taken in their entirety. Observations made on launching at a distance and on the part played by the presence of B in the visual field before the impact, as well as certain other findings, clearly show that the intervention of the Approach and Withdrawal Effects is not absolutely necessary for the structure of the Launching Effect to be formed.[41]

For this reason I have looked for a new formula which applies more generally, and which also accounts for the close relationship, experimentally conformed, between launching and entraining (p. 149).

The first phase of the two Type-experiments is identical: A begins to move, goes towards B, which is at rest, and joins it. The third phase, however, is in part different: in the case of entraining the two objects are joined together in movement and integrated in a single total configuration, while in the case of launching B alone is moving while A has stopped.

A substitution therefore occurs as a result of the processes which

[41] Of course this in no way excludes the possibility that the relations of 'frame of reference', 'polarisation of the movement', and 'inversion of polarity' may play a fairly important part in certain particular cases of launching or entraining.

developed during the second phase; and this phase thus appears once again as a period of transition, in the course of which a causal structure is established which makes the bridge between the first and last phase.

The conditions in which this structure arises are similar in principle to those which we met in the case of the Entraining Effect, since here too there is a conflict situation. In this case there is opposition between (i) the tendency to permanence of the kinematic states in the first phase (A moving, B at rest) and (ii) the effects of the stimulus-system operating in the second (A at rest, B moving).

Several experiments described in the main body of this book show among other things that the launching situation produces conditions favourable to the operation of the factor of 'good continuation'. This factor tends to ensure that the movement is unitary and continuous and that the identity of the object performing it is maintained, even in spite of the hiatus introduced physically at the point of impact. This can be proved in different ways. For example, if by some means one makes the distinction between the objects at the point of impact less clear, the movement of object A will appear to continue without interruption along the whole length of the path, and will include within it the movement performed by object B (compare pp. 47 seq.).

In normal observation conditions, however, this tendency towards continuity of the movement comes up against the fact that from the moment of impact we see both the halt of A and the start of B's displacement.[42]

It is here that the conflict lies; and, as with the Entraining Effect, this conflict is resolved by the formation of a hybrid and ephemeral perceptual structure in which traces of both tendencies are found, viz. the tendency towards permanence and the tendency to see only what corresponds to the present stimuli. This structure can be thought of as follows: although A has stopped, the movement actually performed by B continues to 'belong' phenomenally to A, i.e. it appears as a *prolongation* of the latter's movement during the short period of the second phase. B, on the other hand, retains its character of inertia as in the case of the Entraining Effect, and seems simply to be displaced by this movement of A (see earlier, pp. 333 seq.).

In other words, there occurs a phenomenal duplication of the move-

[42] It should be remembered that in the case of launching-in-flight, where object B is already moving before the impact, there needs to be an abrupt change of speed at this point if the structure of launching is to be set up.

ment performed by B, in the sense that this movement appears momentarily under a double aspect—prolongation of the previous movement of object A, and simple displacement of B. That being so, it must in the last analysis be the already-moving A which gives the appearance of moving B by pushing or launching it; and this is another form of ampliation, very similar, as can be seen, to that which is found in the Entraining Effect (compare p. 319).

The idea that the movement performed by B can apparently 'belong' to object A, which is stationary, even during the fraction of a second which the second phase of the experiment takes, may seem difficult to accept. It becomes more intelligible, however, if we think of the relative autonomy of phenomenal movement in relation to the object performing it—something which has been demonstrated by many experiments—and if we consider the nature of the relationship linking them.

Just as movement is not a constitutive property, and does not determine in any intrinsic way the character of the object performing it, so in the same way the object's own characteristics do not make up the movement as such, since the movement's only essential properties are its orientation, its direction, its speed, and its acceleration. 'Belonging to such and such an object' is merely an extrinsic qualification, a sort of label attached to the movement. Thus it is perfectly conceivable that the displacement of one object should seem to be the prolongation of another object's movement.

This structure, however, can be only an unstable one, and necessarily ephemeral, since the farther away object B is from A, the longer is the time since object A was itself moving, and the more therefore must the influence of the tendency towards permanence disappear. When the limit of the radius of action is reached, B becomes itself the performer of the movement, and this marks the beginning of the third phase.

It will perhaps be remembered that we tried to check our original theory by a series of experiments involving camouflage of the Launching Effect (pp. 72 seq.); and the question may arise as to whether these experiments are compatible with the modification which we have now introduced in the theory. There is in fact no incompatibility, since the point with which we were particularly concerned in those experiments was common to both forms of the theory; what was involved was that characteristic combination of the *movement* of the active object and the *displacement* of the passive one which the phenomenal duplication

brings about (pp. 140–141). In the experiments in question we tried to prevent the formation of such a combination by complicating the experimental situation of launching by the introduction of other elements which should ensure the integration of B's movement into different structures—to-and-fro movements, group movement, symmetrical movements, contraction, etc. The results obtained in these conditions have of course lost nothing of their demonstrative value.

There is, however, an objection to our theory which is immediately apparent. This is founded on the possibility of producing impressions of launching at a distance.[43] That this can be done is beyond dispute, even in cases where the space separating the objects seems absolutely empty.[44] This at first sight seems incompatible with the possibility of a continuity of movement. As this objection is a serious one, we must pause to consider it.

First we must note that we are concerned here with movements, i.e. processes which possess a temporal and spatial aspect.

Now in the case of the first of these aspects, the temporal one, it is absolutely necessary both in the case of launching by contact and in that of launching at a distance that there should not be any perceptible interruption in the course of the events. As soon as a time interval is introduced—of the same length in both cases—between the stopping of A and the departure of B, causal responses of launching disappear.[45] This is a fact of fundamental importance. It shows indeed that temporal continuity is a necessary condition for the formation of the causal structure.

Experiment shows, however, that spatial contiguity, although providing the optimum conditions for the Launching Effect, is not absolutely necessary for the production of it if the two paths are similar in form (straight or curved) and so placed that one is a prolongation of the other (pp. 101 seq.). This amounts to saying that the movement performed by B can seem to be the continuation of that of A, even though

[43] See pp. 99 seq. of this book. Also M. YÉLA, Phenomenal Causation at a Distance, *Quart. J. Exp. Psychol.*, 4, 1952, 139–154. Also J. PIAGET and M. LAMBERCIER, La causalité perceptive visuelle chez l'enfant et chez l'adulte, *Arch. de Psychol.*, XXXVI, 1958, pp. 90 seq.

[44] See M. YÉLA, Phenomenal Causation at a Distance, op. cit., p. 142. Since I myself took part in this experiment, I can confirm the point. It is certain that perfect impressions of launching at a distance *can* be produced without any apparent intermediary, whether rigid or elastic, between the objects.

[45] Compare p. 99 of this book. Also M. YÉLA, Phenomenal Causation at a Distance, op. cit., p. 143.

there is an empty space between them. Now there are plenty of examples which support this hypothesis. First there is the example of static configurations: a line or a curve can clearly be interrupted over a certain stretch without this necessarily destroying the impression that the two sections form a whole and that one of them is a prolongation of the other. Similarly in the case of group entraining, as we have seen, or even in the most simple case of a group of points in motion, the distance between their paths does not in any way hinder their kinematic integration as long as it is not too great, and provided above all that the temporal properties of their courses are strictly identical. Here, too, the temporal conditions need to be exact, as is shown by the segregative effect produced by a difference of speed in the simultaneous displacements of the objects.

It is therefore by no means impossible that the displacement of object B in the second phase of launching at a distance should seem to be the continuation of that performed in the first phase by object A. Nevertheless the conditions of such experiments are clearly less favourable for establishing the structure of the Launching Effect; and they become less favourable still as the arrival-point of object A and the departure-point of object B become farther apart, as is revealed by the fall in frequency of causal responses when the distance increases.[46]

When the responses of the subjects show the presence of launchings, however, the perceptual structure has to be similar to that of launching by contact; in other words it must likewise involve the phenomenal duplication characteristic of ampliation of the movement.[47] As I have just shown, this is in no way incompatible with our present theory.

3. GENERAL CONCLUSION AND DISCUSSION

Now that we have reached the final stage of the programme laid down at the start of this appendix (p. 311), the time has come to pick out the essentials from the data collected so far, in order to see the extent to which they contribute to the solution of our problem.

This problem originated, we should remember, in a commonplace observation. It is true to say that terms having a causal significance are used by everyone for the purpose of indicating the varied concatena-

[46] M. YÉLA, Phenomenal Causation at a Distance, op. cit., p. 142.

[47] This is confirmed by the fact that the radius of action is of the same order of size in both cases. Compare M. YÉLA, Phenomenal Causation at a Distance, op. cit., p. 150.

tions of physical events which are constantly to be observed during ordinary life. It is also true, however, that these terms can have a different implication, even in the opinion of the speakers themselves, according to the circumstances, and that this holds in ordinary life no less than in the laboratory.

Very often they are used to refer to 'causes' which are not observed but which are known to be operative in similar circumstances and which enable the succession between events to be 'explained' by physical laws.

In other cases, however, and in particular those of entraining (or pushing), launching, and their derivatives, subjects say that they actually *see* the cause at work. They claim, for example, that they *see* an object *make another object go forward*, and that they see this as clearly and immediately as in other circumstances they see two moving objects passing or overtaking one another.

These assertions show beyond any doubt that a difference of a perceptual kind is involved here; and it is this which gives rise to our problem, since we may well ask ourselves whether it is possible to obtain more precise information as to the conditions in which observers find it necessary to use these terms, and whether it is possible to reach some understanding of why they speak, in one form or another, of 'knowing' in the first case and of 'seeing' in the second.

All the work which I have carried out from the start of my research on this subject has had as its main aim to provide a satisfactory answer to this question.

The previous pages have shown that this work consists in formulating a series of hypotheses about the perceptual structures which give rise to responses of launching and entraining, and then in trying to justify these hypotheses experimentally *pari passu* with the advance of the analysis. The final result is an overall theory which applies to the two fundamental forms of perceived mechanical causality and whose essential nature can be summarised in a few statements.

In schematic outline the Type-experiments comprise three phases. The first phase is identical in both cases; it amounts simply to a movement of the motor object in the direction of the passive object, and ends when the two objects are touching at the moment of impact.

The second phase is characterised by an evolution in structure lasting a short instant and comprising the 'causal structure' in the strict sense, and it ends when a new and stabilised structure is formed.

In the third phase the operation is accomplished, and the passive

object which had been motionless at the start now begins to move actively, whether united to the motor object in a total configuration in movement, as in the case of entraining, or moving on its own with its own movement, as in the case of launching.

The essential step is thus that of the second phase. To understand the evolution which occurs at this moment, we need to take into account the nature of the change in stimulation which gives rise to it.

In the two Type-experiments the main feature of this change is that the passive object, formerly motionless, starts to move at the moment of impact. The result is a conflict situation which militates against the abrupt passage from the initial perceptual structure to the final one, and which give rise to the formation of a structure of transition between them.

Now since the stimulus-conditions have been only partially changed, a tendency becomes apparent, for a fraction of a second, towards permanence of the states of movement and immobility (inertia) existing at the end of the first phase; in other words there is a tendency towards the apparent continuation both of the motor object's movement and the passive object's inertia. That this is the case can in fact be experimentally demonstrated.

This tendency, however, clearly comes up against the influence of the new stimulus-conditions which comprise the movement of the passive object and in the case of launching the immobilisation of the motor object.

The total experimental situation thus has contradictory demands, which can end only in an impasse, a blockage, or else in a compromise solution which satisfies them only partially and in a way which is necessarily provisional.

It is the latter which in fact occurs. This compromise is made possible by the combined intervention of psychological factors which can lead (if we reduce the exposition of the theory to its simplest terms) to two processes—that of kinematic integration and that of phenomenal duplication.

Kinematic integration ensures the apparent unity of the movement during the short duration of the second phase by operating in favour of the pre-existing movement of the motor object. Because of phenomenal duplication, however, this movement during the time in question presents a double aspect; it is both the motor object's own movement and the simple displacement of the passive object, which being apparently inert does not at this moment possess any movement of its own.

In the case of the Entraining Effect kinematic integration is due to the action of 'common fate'; this arises because the displacement of the passive object, B, occurs conjointly with that of the active object, A, and is in the same direction and at the same speed.

In the case of the Launching Effect it is the principle of 'good continuation' which is operative; kinematic integration occurs because the displacement of the passive object is in the same direction as the path of the active object before it stopped.

The 'compromise' character of these two structures is clear. Both carry the sign of opposing demands in the experimental conditions, viz. permanence on the one hand and change in the stimulus-system on the other.

Because of the effect of permanence, there is in both cases *unity of phenomenal movement* and exclusive belonging of this movement to the active object, A, even though B has started to move. Yet because of the actual stimulus-system, the movement of B is perceived, even though only in the form of a simple *passive displacement*, brought about by the movement of the active object, with the passive object remaining inert until the final phase.

It is clear, however, that structures of this kind can be only transitory, since the permanence in the characters of the initial phase must necessarily lose its influence with the passage of time; soon afterwards, when the third phase begins, it is the actual stimulus-conditions which determine how the perception is structured.

As was pointed out a moment ago, it is the ephemeral structure of the second phase which is essential from the causal point of view. This is plainly the result of the fact that from this point, on account of phenomenal duplication, the movement of the motor object acquires the new property of seeming to 'displace in addition' the object moved. Here we have the really crucial moment, and it is this situation that we have called 'ampliation of the movement', our purpose being to designate by a special name the process, important but momentary, during which the movement of the active object apparently extends to the displacement of the passive object.

This view, so I believe, supplies the solution to our problem.

In the first place it enables us to understand how it is that the experimental conditions of entraining and launching can establish the hybrid structure of the second phase.

It also enables us to understand why, when such a structure is estab-

lished, subjects can communicate adequately what they perceive only by saying that they *see* the motor object make the second object go forward.

Thirdly, since phenomenal duplication occurs at the moment when the passive object starts to move, it is clear that the movement of the motor object must seem to be the origin of the displacement of the passive object. It is as a result of this that ampliation of the movement has its productive character.

Having presented my own point of view, I should like now to compare it briefly with that recently expressed by Piaget in a number of publications.[48] I have been very much gratified by the interest which Piaget has taken in my own work, not only because of the long-standing friendship between us but also because of the exceptional competence which he has acquired in this field as a result of his earlier investigations both on genetic psychology and on problems of perception.

I was pleased to find that recent experimental results obtained in Geneva had confirmed and on the whole fitted in with my own findings, and also that Piaget's views coincide with my own on a number of more theoretical points, in particular with regard to phenomenal duplication and ampliation of the movement.

Yet in spite of the desire which he has himself kindly expressed, and which of course I share, to reach complete agreement, there are certain points of considerable importance where our opinions diverge.

These undoubtedly arise in large measure as a result of differences of a more general kind between our respective views about the processes of perception and ideation; and for this reason a complete discussion would be too long an undertaking to be considered here.

I shall therefore limit myself to an examination of a number of points which relate specifically to our present problem, in the hope that this exposition will contribute in some degree towards clarifying our respective positions.

One of the differences between us is that, in my opinion, the concept of ampliation has an 'explanatory' value, while for Piaget its value is purely 'descriptive'.

[48] See in this connexion part II of J. PIAGET and M. LAMBERCIER, La causalité perceptive visuelle, op. cit.; also J. PIAGET and J. MAROUN, La localisation des impressions d'impact dans la causalité perceptive tactile-kinesthésique, *Arch. de Psychol.*, XXXVI, 1958, 202–235. An excellent summary of his whole theory will be found in J. PIAGET, *Les mécanismes perceptifs*, Paris, Presses Universitaires de France, 1961, 197–308.

Enough has been said both in my earlier work and here on the sense in which I am using 'explanatory' in this context. Let me say once again, however, that what I wanted to 'explain' was the fact that subjects made use in their responses of terms having causal significance when they were placed in clearly defined conditions. Now it seems to me that my hypotheses with regard to the properties which characterise the structure of ampliation enable us to understand why this structure necessarily demands the use of such terms. This presupposes, of course, that responses should be considered as causal without restriction or further qualification, provided they indicate that one object has been set in movement by another. Now such a view seems quite justified, since 'setting in movement' implies the *production* of the passive object's movement by the active one, and the character of '*productivity*' is undoubtedly the most general hallmark of the idea of cause, at any rate as it occurs in unsophisticated thinking. Now it is this 'unsophisticated' idea which is in question here, i.e. the notion which ordinary people have about causal influences, an idea very different from the sophisticated ones which are the result of intellectual elaboration on the manifold data of experience. Indeed, it is surprising how often we find that this naïve idea, which implies a sort of 'creation' and which in this respect is like Piaget's magico-phenomenalist form of causality, leaves traces of itself even sometimes among people who are highly educated in disciplines other than that of physics. Moreover, as I have said elsewhere,[49] this naïve popular idea of causality often differs in the last resort from that of children and primitive people only in that the civilised adult believes, on account of his education, that the succession of events which take place in the physical world is controlled by laws which science is able to discover and explain.

This brings us to the consideration of another point in Piaget's thesis, where he claims that perceived causality must be linked with the constancy phenomena, e.g. constancy of colour in spite of changes in illumination, constancy of size in spite of changes in distance, etc. Piaget has built up an extremely ingenious theory to justify this view, in which he offers a 'model of compensation' analogous to those which he has established for the constancies and capable of being represented by a series of equations. These equations enable him to establish a balance between the speeds of the active and passive objects as they change at the point of impact; but this can be done only by bringing in

[49] A. MICHOTTE, La causalité phénoménale, *Studium Generale*, p. 390.

two other factors; first 'resistance', and secondly a dynamic factor, the impression of 'pushing'.

These equations clearly do not have a descriptive rôle; the subject who sees A launch or entrain B certainly does not perceive a relationship of equality between a loss of speed in object A (when this occurs) and an increase of speed in object B, accompanied by a 'push' which encounters a 'resistance'. What is involved here is a 'model of compensation', i.e. an explanatory construction which—if I understand correctly what Piaget means, and I am not completely sure of this—has two functions: it makes intelligible how it is that a particular idea of causality, of an elaborate sort involving equality between the cause and the effect, can correspond to the 'impressions' of the subjects, and it enables us to make deductions having predictive value. In addition, Piaget insists that the 'factors' which play a part in his formulations are not introduced *ad hoc* or arbitrarily, but that they reflect what to the subjects are dynamic 'impressions' of pushing and of resistance.

The introduction of such factors as hypotheses in an explanatory theory is perfectly legitimate in principle, as has already been pointed out (p. 308), provided the subject's responses indicate that this is necessary. Here, however, this does not seem to me to be the case.

In the first place it is difficult, I think, to establish the existence of any relationship between perceived causality and the constancies. There is certainly the tendency towards phenomenal permanence in the states of movement in the first phase and there is phenomenal duplication, both of which recall the mechanism of the constancies; but it is a question here of transitory, unstable events, characteristic of the short period (i.e. the second phase) during which a stabilised and permanent structure is being established, whereas the constancies, as we ordinarily experience them, are stabilised events, and it is in these stabilised events that we find the conservation of particular properties by means of phenomenal duplication.

In addition, productivity seems to me to be the opposite of constancy. This is a point which I have often emphasised previously. At the moment when the second phase begins in both entraining and launching, there is clearly a *new happening*, viz. the starting off of the passive object; and the event which now occurs gives the appearance of being linked with the pre-existing movement of object A, since it is A in movement which seems from the moment of impact to start displacing B as well. Now the unsophisticated idea of causality implied by the

terms 'launching' and 'entraining' refers, in my opinion, to precisely this; and it is quite to be expected that an unsophisticated idea which is spontaneous and unelaborated should also be very close in its content to what is given at the level of perception.

Next, I should like to say a little in connexion with Piaget's 'impressions of resistance' and 'dynamic impressions of pushing', and the part which they play in subjects' responses.

As far as resistance is concerned, having myself made thousands of observations in the most varied conditions, and having also collected thousands of responses from other subjects, I think I can say with some assurance that only on very rare occasions is any mention made of it. On this point Piaget's results agree with mine, I think, as far as spontaneous responses by the subjects are concerned; but if leading questions are put to them the matter is very different. For my part, of course, I am opposed, rightly or wrongly, to the use of this method; but however that may be, we clearly cannot exclude *a priori* the possibility that subjects failed to mention these 'impressions' in their responses, perhaps through negligence, perhaps because they attached no importance to such details, or perhaps for some other reason.

This, however, seems to me very unlikely. In the first place their silence on this point appears strange if one considers the minutiae of detail supplied by some of them in their responses; there were plenty of unimportant points which they went out of their way to record. Again, there are the negative results (from the point of view of causal structures) in Levelt's experiments on braking, which will be described in the following section. In addition I have tried to find out from the start of my investigations if the relative size of the passive object in relation to the active one had any influence on the causal character of the responses, as one certainly would have expected *a priori*. Now although in some experiments the surface of the passive object was at least a hundred times larger than that of the active one, I have noticed only the apparent differences in speed indicated by Brown's laws; and an 'impression' of reduced speed can obviously not be considered as an 'impression' of resistance.

Finally, there are the cases—and they are of crucial importance in my opinion—in which the movement of object A does not undergo any loss of apparent speed when B starts to move. In this connexion we may recall the very informative results obtained from the entraining experi-

ments carried out by Michotte, Knops, and Coen-Gelders—results which show that the Entraining Effect was regarded as optimal by the subjects when the common speed of the objects after the impact remained the same as was the speed of the motor object on its own, and very much better, in particular, than when there was a slowing down, even though this might be thought to be a sign of 'resistance'.

With regard to the dynamic aspect of perceived causality, the idea of 'the dynamic impression of pushing' which Piaget introduces seems to me to lead to confusion for several reasons. On p. 151 of *La causalité perceptive visuelle* he carefully defines this pushing as being 'the impression of the influence exerted on the passive object at the moment of the impact' (i.e. the launching, triggering, or entraining). Now the 'push' in this sense necessarily includes both the movement of the active object before the impact and that of the passive one afterwards. Now it is clear when we have experiences of this kind that it is only because it is in movement that the active object 'exerts an influence' on the passive one; it is also clear that this 'influence exerted on the passive object' is apparent only in the form of this object's displacement. Moreover it is clear that if we talk of 'exerting an influence' this presupposes a phenomenal link between the two objects. Now that being so, it is not legitimate to consider the 'push' as a factor of compensation explaining the equivalence between cause and effect, since the effect is already one element constituting this 'push'. It seems that there is here an objection of a fundamental kind to Piaget's proposed 'system of equations'.

Now the definition which he gives of 'push' seems to fit in with the structure of ampliation; yet he criticises my theory of ampliation on the grounds that it 'cannot explain the dynamic character of the causal impression' because it does not take account of the objects' movements. The question here clearly turns on the sense given to the word 'dynamic'. Indeed one of the essential points of my own theory is to show how, because of phenomenal duplication, ampliation involves an aspect of productivity, which indeed is what the term 'dynamic' basically implies when it means 'cause of movement'.

It is true that the word 'dynamic' can often have an 'intensive' connotation which is particularly applicable, in the kinaesthetic sphere, to the impression of greater or less muscular effort which sometimes accompanies launching or entraining. The question then arises as to whether there is anything corresponding to this in the visual sphere.

There is a striking analogy, it seems to me, in the case of the 'violence' of the blow—as observed visually—at the moment of impact. In both cases there are variables capable of presenting differences in intensity which give the event a fairly marked character of 'force'. Moreover kinaesthetic effort and the visual character of violence attain their maximum value when they are followed by no movement at all, i.e. when there is no perceptible effect (compare pp. 62–3). Conversely they can be reduced almost to zero without the causal character being altered. It is in fact possible for a person to have a perfectly good impression of entraining if he moves his hand (with his eyes shut) and his fingers encounter an object so light that, even though it can be perceived tactually, its entraining occurs without any supraliminal extra effort and without any break in the uniformity of the movement; and the same holds in cases of visual causality (e.g. those described both by myself on pp. 100, 107, and 159, and by Yéla on p. 142 of *Phenomenal Causation at a Distance*) where there is no actual blow.

These last points show that what is involved is not a property belonging exclusively to causal 'impressions', although one might suppose this and although it might seem to be indicated by the fact that, at least in the case of the Launching Effect, there is an obvious parallelism between the drop in speed at the point of impact (which brings about the violence of the blow) and the causal character of what follows.

It should be emphasised, too, that subjects regularly indicate gradual differences of quite another kind between their causal impressions. They speak of these impressions as being 'better' or 'worse', 'clearer' or 'less clear', 'more satisfactory' or 'less satisfactory', and so on. These differences seem to be qualitative, and they represent a whole series of nuances intermediate between the extreme case of total independence of the two movements and that of the clear production of one movement by the other. It is not impossible that they represent the degree to which the displacements of the two objects are identified during the period of phenomenal duplication; but however that may be, it is certain that they relate to the causal character as such, and that they are to be found in all conditions which arise in experiments on perceived causality.

One final point remains to be considered, namely the relationships between tactile-kinaesthetic perceived causality and visual causality. I am in full agreement with Piaget in recognising that the stimulus-conditions necessary for the formation of causal structures are to be

found in the child's development much earlier in the tactile-kinaesthetic sphere than in the visual sphere; and I also think it likely that causal structures are in fact formed with a time-lag of this kind. In that case the tactile-kinaesthetic sphere would have a chronological priority in this matter as in many others (compare p. 275).

I am less convinced, however, of the existence of a genetic link, brought about by assimilation, between the establishment of causal structures in the two spheres. Piaget's arguments, based as they are in particular on the dynamic 'impressions' of pushing, etc., and on the fact that causal responses of launching at a distance are less frequent in children than in adults, do not seem to me to be decisive. As far as the first is concerned, my view has already been given, and, as for the second, there are plenty of other hypotheses, e.g. the influence of maturation or learning, which provide possible answers.

The issue is one of fact, and at the present moment cannot be settled directly. For this reason any opinion must be based on indirect evidence. It is a subject on which we may express considerable scepticism in view of the failure of numerous attempts to explain some of the properties of visual structures in terms of eye-movements, and in view of the extreme divergencies which often occur between visual perceptions of shape and size and tactile-kinaesthetic ones.

Admittedly examples could be cited which point in the opposite direction; but this shows, to my way of thinking, only that we should regard the matter as still open. In the absence of rigorous demonstration one is forced to be content with probabilities; and what one regards as probable will necessarily vary according to one's general views about the mechanisms of perception and its development.

4. 'CAUSE', 'CONDITION', AND 'DEPENDENCE'

As was indicated in the previous section, the essential feature of my theory, both in its new form and in the original one, is that it involves the notion of ampliation of the movement. Now this structure presupposes a combination of movements whose occurrence is difficult to conceive apart from the fundamental cases of entraining and launching or their derivatives (such as traction, trace-making, animal movement, etc.); and furthermore it is hard to see how the character of productivity could be intelligible without ampliation. As a result I became convinced of the fundamental point that perceived causality was the prerogative of these particular kinematic structures (p. 250).

In ordinary life, however, as was pointed out above, we frequently meet innumerable situations which are described or expressed in terms having a causal significance, even though the corresponding perceptual structures are certainly nothing like that of ampliation; and I have already put forward a number of hypotheses to explain why causal terms are used in these circumstances.[50]

Since that time, however, various pieces of research have supplied important new data, which certainly give us grounds for reconsidering the matter.

Before doing so, however, it will be helpful, I think, to recall what was said at the outset about the logic of this kind of research and in particular about the conditions in which 'causal responses' make possible the assumption, and then the demonstration, that they are the expression of specific perceptual structures.

Now it is clear that almost all experiments in this field, both our own and those of others, and with the exception only of the paradoxical cases, reproduce in a somewhat simplified form situations which we meet in ordinary life and which we customarily describe by means of causal expressions. Indeed, if it were not so, these experiments would not be of much interest.

It is thus possible, *a priori*, that causal responses arise as a result of the similarity between the situations, even when no perceptual causal structure is operative and when responses are simply dictated by acquired knowledge of the subject-matter of physics, whether at the common-sense or scientific level (compare p. 311).

This being so, it is of course not sufficient, in order to prove the existence of 'causal impressions', to show that certain experimental situations give rise with fairly high frequency to causal responses. This is quite obvious.

Now a series of experiments carried out in our laboratory by Levelt has supplied some very interesting information in this connexion.[51] Their object was to examine if a schematic representation of certain situations such as we ordinarily come across could give rise to responses mentioning 'braking' (compare p. 157).

By means of the disc method, subjects were made to see a rectangle

[50] See pp. 256 and 260 of this book. See also A. MICHOTTE, La perception de la fonction 'outil', *Essays in Psychology dedicated to David Katz*. Almquist, Uppsala, 1951, p. 210, and La causalité phénoménale, *Studium Generale*, p. 389.

[51] W. J. M. LEVELT, Motion Braking and the Perception of Causality, *Causalité, Permanence, et Réalité Phénoménales*, op. cit., pp. 244–258.

5 by 10 mm., object A, which moved along in front of a uniform background along the length of the slit. Its initial speed was 31 cm. per sec., but after a distance of a few centimetres this dropped abruptly to 5 cm. per sec. Subjects were told simply to 'describe what they saw' in the apparatus. Fifteen new subjects took part in the experiment, of whom three mentioned braking.

Next Levelt made the conditions more complicated by dividing the background into two sections of different colours; and with one group of subjects the slowing down was made to coincide exactly with the vertical limit separating the two sections of the background, while with other groups it was made to coincide with a point a little to one side or the other of this limit; the exact place was found to be unimportant. Now, out of seventy-four new subjects only ten mentioned braking. (The difference between this result and the previous one is not statistically significant.)

Next, a second object, B, of the same size, was brought in. It was of a different colour from A, and A seemed to pass in front of it during its own displacement, slowing down at the moment when it reached it. In these conditions, with fifty new subjects, the number of braking responses rose to 34%. (The difference as compared with the previous results is this time statistically significant.)

Finally, when the slowing down was limited to the time and distance during which A was passing in front of B, the frequency of positive responses increased to 58% with two further groups comprising sixty-two new subjects. (The difference from the previous result is again statistically significant.)

As can be seen, there is in these experiments a steady progression. The more the elements in the situation coincide—object with object, start with start, time and length with time and length—the more frequent are the responses mentioning a causal link, which indeed is what one might expect. The explanatory principles which the subjects invoked included resistances to the movement arising from friction or viscosity, magnetic effects, and so on; and they were of course based on acquired knowledge. The part played by acquired knowledge has been well displayed by another experiment, one in which Levelt reversed the speeds used in the last experiment in such a way that the movement became quicker instead of slowing down during the time when it was passing over the second object. In these conditions there were only three responses having a causal significance among a group of twenty

new subjects (15% instead of 58%); and the subjects found it very difficult to supply an explanation for the phenomenon.

It should also be noted that among the very numerous subjects taking part in these experiments (two hundred and twenty-one new subjects altogether), those who gave braking responses (sixty-nine altogether) never made any mention of a direct or immediate impression of a causal influence of the sort which occurred in the responses which I shall discuss in a moment and which have been observed in other conditions.

It is therefore valid to assume, pending evidence to the contrary, that the responses given in Levelt's experimental situations were simply suggested to the subjects, on the basis of their acquired knowledge, from observation of the coincidences, both spatial and temporal, between these situations and those of ordinary life.

Similar responses tend to predominate when the experiments are not presented in isolation but form part of a series some of which are of a kind to demand causal responses. One is thus creating an intellectual environment orientated towards 'causality', which as a result of the effects of expectation can even contribute towards the forming of the structure of ampliation in the case of somewhat ambiguous stimuli. We ourselves have come across this fact repeatedly, and Grüber has carried out some interesting experiments on the question.[52]

For this reason we have for a long time adopted the procedure—a very extravagant one, alas!, as regards number of subjects required—of using single and isolated presentations and having new subjects[53] when delicate problems were involved in which the effect of 'attention' or 'perseveration' would be such as to vitiate our results.

Now it would be arbitrary and quite erroneous if as a full account of the results which I shall now discuss we were to try to use the same explanations that were appropriate in the case of Levelt's work. As will be seen, however, the considerations just mentioned go to make up a part of the solution; and in addition they show the need to proceed with extreme circumspection on this matter.

All things considered, and in the light of a whole collection of confirmatory findings, it seems beyond possible doubt that subjects sometimes insist that they have immediate evidence of causal interaction, even though there could not have been ampliation since the movements were in entirely different directions.

[52] H. E. GRÜBER, C. D. FINK, and V. DAMM, Effects of experience, op. cit., pp. 91–93.

[53] See above, p. 309.

Several writers have stressed the fact that in some of their experiments the subjects expressly asserted that they were not making inductions based on reasoning and were not interpreting what they saw, but were reporting a specific and immediate perceptual experience. (See, for instance, the work of Grüber, Metelli, Akio Ono, Geiger, and others.)

Moreover, these claims have been confirmed by means of some of the criteria which we ourselves have used. In particular, the method of concomitant variation has been applied by Grüber and Akio Ono, as well as by Tognazzo.

In addition there is the particularly interesting fact that Grüber and Akio Ono have also been able to produce typical paradoxical cases. Both their investigations involved the movement of a lever apparently resting on a support.[54] By means of a suitable device it was possible for this lever to fall, or not to fall, when the support was withdrawn. Now in some of Grüber's experiments the lever when at rest was not actually touching the support, but there was an empty space between them which could reach a value of more than 6 cm.; and in Akio Ono's experiments the lever rose instead of falling when the support was removed.[55]

Now both investigators have successfully recorded causal responses in these conditions, in the direct sense mentioned just now.

Experiments of this sort are clearly very telling because they enable us to exclude the influence of acquired knowledge.

Very much the same undoubtedly holds in the case of the experiment which Kanisza and Metelli call that of 'inverse launching'. This was carried out as follows: two objects in a group moved towards a third, which was motionless, and stopped when they had become level with it and were on either side of it; at this moment the third object started to move in the opposite direction to that of the previous movement.[56] Kanisza and Metelli point out that there is a very clear causal impression in these conditions, though unfortunately they do not give further details with regard to subjects, etc. Now we should note that the movements performed in this experiment constitute an outward and return

[54] For details of Grüber's research, see note 3, p. 305.

[55] AKIO ONO, personal communication. It has not been possible for me to consult his original article.

[56] G. KANISZA and F. METELLI, L'orientation relative des mouvements dans la perception de la causalité, *Proc. XVth Int. Cong. Psychol.* (Brussels, 1957), North Holland Publ. Co., Amsterdam, 1959, 290.

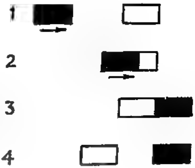

FIG. 22

journey, one which has the remarkable peculiarity of being able to give the impression of a continuous movement despite the change in direction (compare p. 161 of this book). One cannot therefore exclude *a priori* the possibility that the return journey appears as a continuation of the previous movement of the group, or, strictly, of its centre of gravity. I myself have carried out a similar experiment using the disc method. (For a diagrammatic representation see Fig. 22.)

Exp. 102. Two small rectangles of 5 by 8 mm., one black, one red, are present in the slit at a distance of 5 cm. from each other. A starts to move, goes towards B at a speed of 30 cm. per sec., and stops as soon as it has passed beyond it. At this moment B starts to move in the opposite direction at a speed of 4·5 cm. per sec., and stops in its turn after travelling for 3 cm.

Fifteen subjects took part in this experiment, eight of whom were experienced, and seven new. There were seven responses (47%) indicating a 'triggering' of B's movement; they were given spontaneously by four new subjects and three experienced ones. As against this, seven responses indicated that the two movements were independent, and one case was doubtful.

Thus, although the experiment was slightly different from that of Metelli, I, too, found that causal responses in such conditions are sometimes possible.

The case of 'attraction', to which several writers have turned their attention, is more problematic. It is clear that ampliation is necessarily out of the question here since (i) the movements of the objects are occurring in opposite directions, and (ii) they start from points which are at some distance from each other in such a way that the one clearly cannot appear as the prolongation of the other.

In spite of this, Kanisza, Metelli and Tognazzo, and also Geiger have stated that in numerous experimental situations with similar conditions of movement, and even when one of the objects was motionless, subjects gave causal responses. The significance to be attached to these responses in such cases seems to me an extremely difficult matter.

In view of my own observations, however, I think that in some cases

at least there may be triggerings similar to those mentioned in connexion with the previous experiment.[57]

This brings us to a consideration which I believe to be important. It seems that the cases mentioned in this section, even if they do not involve ampliation, are very close to the cases of triggering which we have observed in extremely varied conditions. We may mention in

[57] Since Metelli has been kind enough to send me his experimental material, I have had the opportunity to repeat some of his experiments, and I admire their ingenuity. In particular I have tried out one of his most important ones, which has been called an experiment of 'multiple lengthening', on twenty-three subjects, eight of them experienced and fifteen of them new. It was originally described by Kanisza and Metelli, and was later repeated with forty subjects by Metelli and Tognazzo.

The subject is presented with a white circle, around which four small white squares are set symmetrically at some distance from the periphery of the circle. At a certain moment four rectilinear appendages open out from the circle in the direction of the squares, and stop abruptly before they reach them; the squares then start to move in their turn, at a slower speed, towards the appendages and go to join them.

Metelli and Tognazzo obtained 80% attraction responses in these conditions. The same result was obtained in five cases out of eight, or 62%, when I myself did the experiment with experienced subjects, but when I tested fifteen new subjects it occurred only twice, or 13% of the time. For ten of them the movements were independent, and for the three others there was the inversion mentioned by Metelli, the squares being considered as motor objects, not the appendages.

It seems probable that the difference between my results and those of Metelli arises from the fact that I gave my subjects this experiment only, whereas in his research it was interspersed among other similar ones in a series of thirty-nine different experiments, most of them the standard cases of causality—launching, entraining, and traction. This hypothesis is strengthened by the fact that there was a difference in the case of my experiments between the responses of the experienced subjects as compared with those of the new subjects.

The results of another experiment by the same authors must undoubtedly also be explained by the serial effect. It was an experiment in which the path of a moving object deviates at the moment when it approaches a fixed object. This gave rise to 65% attraction responses. This result is very surprising, since, if it were generalised, one might expect countless movements perceived in everyday life to give rise to 'impressions of attraction'! The authors say very little about the interpretation of this result, and indeed it seems that they are quite right not to do so. Incidentally, during my 1948 research, I myself carried out an almost identical experiment on the possibility of making people perceive in certain movements a 'character of intentionality' (see Autobiographie, op. cit., p. 21); this experiment was tried on a large number of subjects and always resulted in negative responses, in which they mentioned a spontaneous change of direction on the part of the moving object.

This does not exclude the possibility that when causal responses occur they require to be interpreted in the same way as the braking responses mentioned above; and this may perhaps be the explanation of what happened in the research of Metelli and Tognazzo.

particular the following situations: (*a*) movements in different directions (p. 101), (*b*) movements having a different phenomenal nature, e.g. the contraction of an object after impact (p. 75), (*c*) the symmetrical withdrawal of two objects after they have come into contact (p. 78), and (*d*) the linking of a movement with the sudden appearance or disappearance of an object (pp. 231 seq.).

The Triggering Effect is often mentioned, too, when the experimental situation, while copying closely that of the Launching Effect, none the less differs from it in certain respects. Examples include launching at a distance when the distance is fairly large, as reported both by myself (p. 100), and by Piaget and Lambercier,[58] and also the case which has received the most attention, that in which there is an ascending ratio of speeds.[59]

We thus have at our disposal a large collection of mutually consistent data which suggest the existence in certain conditions of phenomenal structures *sui generis*, different from those studied earlier, but nevertheless designated alike by the subjects as 'causal'. We must therefore try to make precise what is their character (compare p. 146).

Now observations on triggering supply valuable information on this point. Often the subjects have been quite explicit in their responses, and in particular have insisted on the fact that in the case of triggering the movement of the passive object, B, was not *produced* by the movement of A, the active object, nor by the blow which it dealt, but that none the less it *clearly depended* on it in some way not exactly specified (see pp. 121 and 122).

This last point is crucial. While in the cases of launching and entraining the action exerted by A on B is obvious, has nothing mysterious about it, and demands no explanation, since we actually *see* the movement of A make B go forward, it is quite different here. If the movement of B appears to 'depend' on certain events in which A plays a part, we do not actually *see* either why or how.

Thus subjects often feel the need to look for and imagine an 'explanation' on the basis of acquired knowledge, since the explanation is not immediately present to their senses. Nothing like this is ever found, at least as far as I know, in cases of launching or entraining; the most that

[58] J. PIAGET and M. LAMBERCIER, La causalité perceptive visuelle, op. cit.

[59] See pp. 109 seq. and p. 121. Also PIAGET and LAMBERCIER, op. cit., and D. G. BOYLE, A Contribution to the Study of Phenomenal Causation, *Quart. J. Exp. Psychol.*, 1960, 12, 171–179.

happens is that subjects, to illustrate their responses, mention examples borrowed from ordinary life, as for example when they say in a case of launching that it is as though A 'gave B a kick', 'sent it flying', and things of that kind.

Here, on the other hand, it is to give an account of *the dependence itself* that an appeal is made to factors which are outside the experimental situation—concealed devices or imperceptible physical forces. This is what happens, for example, when typical cases of the Triggering Effect are explained by the operation of a concealed mechanism, an electric shock, or a magnetic force (compare p. 121).

In cases of action at a distance subjects sometimes bring in a rigid intermediary object[60] or an elastic and compressible one.[61] In one of Geiger's experiments, in which a flame could be bent in the direction of an electrode by the creation of an electric field, the subjects attributed the movement to the action of a current of air; and they showed amazement when they discovered that the direction of the flame became different when the electrode was moved—even indeed when the flame was surrounded by a glass tube, because they had no inkling of any plausible explanation for this 'dependence'. Other examples have been quoted by Grüber and by Metelli, and of course the possibilities here are extremely numerous.

A second difference between the cases of launching and entraining on the one hand and that of simple dependence on the other consists in the fact that in the latter case similarity in the movements of the two objects is not required, the kinematic conditions in which dependence is mentioned being variable almost without limit.[62]

Thus in experiments on the fall of bodies, for instance, the support can clearly be withdrawn in all sorts of ways and can perform movements which vary both in direction and speed, without the responses being affected so long as the temporal conditions are adhered to. The same holds for a large number of cases of triggering, whereas launching and entraining responses, as we know, are appreciably modified or even fail to occur at all in such conditions.

[60] See p. 100 of this book. Also M. YÉLA, Phenomenal Causation at a Distance, op. cit., and H. E. GRÜBER, C. D. FINK, and V. DAMM, Effects of experience, op. cit.

[61] See PIAGET et LAMBERCIER, La causalité perceptive visuelle, op. cit.

[62] I originally considered triggering to be a primitive form of launching (compare p. 146); but it seems, in the light of what has just been said, that this account is too narrow in view of the variety of conditions in which subjects say that they see standard cases of triggering.

In view of all this, it seems that the causal responses which the subjects consider authentic, and which one has every reason to believe to be such, should be divided into two categories. The first category comprises only cases of launching, entraining, and their derivatives, where the displacement of the passive object appears at once as having been brought about by the movement of the active one in such a way that the notion of cause is applicable without any ambiguity. The second category comprises cases of simple 'phenomenal dependence' between an antecedent and a consequent which are not intrinsically united, a relationship such that the appearance of the consequent is explicable only in terms of a cause distinct from the antecedent.

This being so, the antecedent should clearly be considered from the logical point of view simply as a *condition* for the operation of the cause. Thus in the case of the fall of the lever, the withdrawal of the support is a condition for the functioning of gravity in the same way as the approach of a magnetic object to a magnet is a condition for the functioning of the force of attraction; similarly, too, in some cases of triggering, the contact of the objects is a condition for the starting up of hidden mechanisms to which the subjects attribute the movement of the passive object.

We should bear in mind that ordinary language totally lacks precision on this point, and that in ordinary discourse we continually confuse cause and condition. This happens, for example, when we say that someone lights up a room when he merely turns a switch or that he causes the water to come into the basin when he merely turns a tap.

It is not simply an imprecision in language which in involved here, however, since, as we know, subjects often spontaneously and expressly indicate that their verbal responses reflect 'an immediate perceptual experience of causality'. The question then arises as to the *psychological* reason why what is logically only a simple condition appears to the subjects as 'causal influence'.

Now this can readily be understood on reflection, since, as we have seen, the dependence which we 'directly perceive' does not in itself possess any particular characteristic, as is well illustrated by some unusual cases, e.g. those reported by Geiger in which the dependence 'simply did not make sense'.

These cases, however, are the exceptional ones, and normally it is quite different, since the total situation in which the antecedent and consequent are integrated is perfectly 'meaningful' for the subject, on

account of the knowledge which he has acquired during his past life. Thus 'perceived dependence', a character belonging to the phenomenal structure of the whole, must necessarily appear as a manifestation, immediately experienced, of the causal relations evoked by the situation. Now we know that an acquired significance, of extrinsic origin, can appear as inherent in the perceptual data to which it applies. This indeed is what happens in the case of all familiar objects which we commonly handle and which derive their significance from the way in which we use them; and the same holds when we are reading the words of a book and have the impression that we are reading not words but 'ideas'—a phenomenon to which attention has often been drawn.

It is therefore understandable that subjects should be able to claim that they have an immediate impression, e.g. that the withdrawal of a support provokes or 'causes' the fall of a lever, or, in a number of 'attraction' situations, that they have the impression that the approach of one object 'causes' the movement of the other towards it, and so on.

From the psychological point of view the essential difference between the Launching Effect and the Entraining Effect on the one hand and cases of simple dependence on the other thus consists, in the last analysis, in the fact that the causal significance is immanent and intrinsic to the perceptual structure itself in the first case, while it is acquired and has an extrinsic origin in the second.

This distinction between the two categories of causal response is thus a necessary one, both from the logical and the psychological point of view. As far as terminology is concerned, it seems to me convenient to continue to use the term 'perceived causality' in cases where there is apparent productivity, as I have done in my earlier work, and to use 'perceived dependence' for causal responses without this character and in which the link is a purely empirical one.

Now that this distinction seems to be established, it should be mentioned that the conditions, whatever they may be, which bring about the appearance of the character of 'dependence' are clearly satisfied in situations of entraining and launching, and this must further reinforce the link which occurs in ampliation. This point fits in too with the fact that there are certainly intermediate cases between complete perceived causality and simple dependence. One of the many examples of this can be seen if we modify the stimulus-conditions in such a way as to pass progressively from the Launching Effect to the Triggering Effect (see pp. 108 seq. and p. 144 seq.); the same holds in entraining experi-

ments when the experimental conditions are such that the possibilities of making an identification between the displacements of the two objects are progressively reduced.

A very large problem, however, still remains to be solved, that of the stimulus-conditions which require to be satisfied in order to establish a structure in which one of the constitutive elements seems to depend on the other.

There can be no doubt, and indeed this has been known for a long time, that temporal relations are extremely important in this connexion; and all the data derived from many different sources, on launching, entraining, and triggering, as described in this book, and on the lever experiments and others, are in agreement on this point.

Temporal conditions, however, are not the sole determinants; and in this connexion there is a good case for examining in particular if repeated presentations of a situation can give rise to dependence where it was absent on the first occasion.[63]

In any case it seems certain that the combined action of the factors of immediate succession and repetition is not sufficient to ensure the formation of perceptual structures of this kind, and that one cannot bring about this type of integration arbitrarily between any one thing and any other thing by using this method alone. In this connexion we may recall the negative results of the experiments which we performed a long time ago on 'qualitative causality' (pp. 242 seq.).

Moreover, the most superficial observation is enough to prove clearly that the rapid and repeated succession of two events can produce very diverse effects from the perceptual point of view. These are described by the subjects, e.g., as 'simple succession', 'belonging' (in which we may include structures which involve symbols), 'dependence', or in other ways according to the circumstances.

'Autonomy', 'belonging', 'dependence', etc., are terms which relate to the basic character of perceptual structures, and it will require further research to discover what differential properties in the stimulus-systems, and in some cases also what conditions of preparedness of the subject, are responsible for forming these types of structure. This is a task for the future.

[63] See A. MICHOTTE, La causalité phénoménale, *Studium Generale*, p. 390.

Summary of Experiments Represented by Diagrams (Figs. 9–22)

The following is a list of the experiments represented by Figs. 9-22, together with the page-numbers, authors, and, in the case of the more important of my own experiments (exps. 96-102), their number according to my original system of numbering.

	Page	Author	Experiment Number
Fig. 9	322	Michotte	
Fig. 10	323	Michotte	96
Fig. 11	323	Thinès	
Fig. 12	325	Crabbé	
Fig. 13	325	Michotte	
Fig. 14	327	Michotte	97
Fig. 15	329	Michotte	98
Fig. 16	331	Michotte	99
Fig. 17	335	Michotte	
Fig. 18	339	Thinès	
Fig. 19	340	Thinès	
Fig. 20(a)	341	Michotte	100(a)
Fig. 20(b)	341	Michotte	100(b)
Fig. 21	343	Michotte	101
Fig. 22	363	Michotte	102

COMMENTARY

Commentary

by T. R. Miles, M.A. (Oxon)

I. INTRODUCTORY

Professor Michotte's experiments have that combination of ingenuity and simplicity which frequently accompanies important contributions to knowledge. In one sense his procedure is extremely simple, particularly his use of the disc method. We all know that interesting optical effects can be produced by the rotation of discs, and even that the results can be considerably altered if parts of the disc are covered. Yet to use this obvious knowledge for systematic investigation and theory-building is, to my mind, an achievement of quite astonishing ingenuity. In addition Michotte has shown himself to have a special flair for reproducing in schematic form the many different kinds of movement-situation which occur in ordinary life, and both his experiments and his incidental examples bring home to us how fascinating and complex even the most familiar movement-situations can be.

The purpose of the present summary (written originally for my own convenience during translation) is to make explicit the logical moves by means of which Michotte develops his argument. It is most important to remember that nowhere in *La Perception de la Causalité* are results quoted merely because they seem entertaining or because they present some incidental perceptual oddity; on the contrary every experiment has its relevance. It therefore seemed to me that readers would be helped if the underlying logic were exhibited in a concise form, so that the reason for each particular set of experimental conditions would never be in doubt. Inevitably some degree of selection has been necessary in the interests of brevity; but I have ensured that all experiments to which Michotte has given a separate number receive a mention of some kind, however brief. In addition to the summary a few explanatory notes have also been included where appropriate.

It should be emphasised that the summary is intended as a supplement to the main text, not as a substitute for it, and will be intelligible only to those who have read the main text first. Also, since it is a summary of the book as originally written, some parts of it do not adequately represent Michotte's present views (1961) as set out in Appendix II.

The remainder of the Commentary comprises two short essays, one entitled *Phenomenology and Scientific Method* and one entitled *Michotte's Experiments and the Views of Hume.*

II. SUMMARY AND NOTES

The main sub divisions of the book are:

1. Introduction (Chapters I and II).
2. Mechanical Causality (Chapters III to XIV).
3. Qualitative Causality (Chapters XV and XVI).
4. The Origin of the Idea of Causality (Chapter XVII).
5. Appendix I (1954). The Trace-making Effect.
6. Appendix II (1961). Theory of Phenomenal Causality. New Perspectives.

Section 2 (on Mechanical Causality) is further subdivided as follows: *Part One* (The Launching Effect), Chapters III to VIII; *Part Two* (The Entraining Effect and its Derivatives), Chapters IX to XIII; *General Conclusions*, Chapter XIV.

INTRODUCTION

Chapter I. The Problem

1. HISTORICAL SURVEY

The views of Hume are discussed, and reference is also made to later associationists (Münsterberg and Ziehen), to Maine de Biran and Durkheim, to Piaget, and to the psychologists of the Gestalt school, Köhler, Duncker, and Metzger.

2. CAUSALITY AND ACTIVITY

In the present research it was discovered that solid objects were unnecessary for producing a causal impression, and that by varying certain conditions it was possible to make this impression appear or disappear at will. To produce a theory of the causal impression the method of genetic analysis was used; that is to say, the attempt was made to find its 'ancestry' in more simple impressions.

Exp. 1. A moves towards B and stops when it has reached it; B then moves off at a slower speed. In these conditions most observers receive the impression that A launches B (the 'Launching Effect').

Exp. 2. This is the same as exp. 1 except that after the contact A and B move on together at the same speed and in the same direction. In these conditions most observers receive the impression that A 'entrains' B or carries it off (the 'Entraining Effect').

The presence of a time-interval between the arrival of A and the departure of B makes the causal impression disappear.

Many types of movement give rise to impressions of 'activity'; one sees the object act, or *do* something. This occurs not only in cases of causality, but also e.g. where A hammers B, and more particularly where there are live movements. Activity and causality should not be confused.

Chapter II. The Experimental Apparatus

Two main methods of experimentation were used, the disc method and the projection method.

MECHANICAL CAUSALITY

Part One—The Launching Effect

Chapter III. The Segregative Influence of the Objects

In the Launching Effect there are two movements. What happens if they are two movements of the same object?

Exp. 3. Object B is suppressed. According to the length of halt-time there are four possible results: (i) an impression of continuous movement, (ii) an impression that the object has become 'caught' on something, (iii) an impression that there is a movement in two stages, and (iv) an impression that there are two separate movements. When A rebounds at varying speeds after the impact (**exp. 4**) no causal impression is found.

It seems to follow that for the occurrence of the causal impression two objects are needed, each performing a movement.

In addition, they both need to be present for a certain time-interval; this is shown by **exp. 5**, where A only is present at the start and dis-

appears on reaching its ordinary stopping-place, B then appearing in movement. Observers in this case report the presence of a single object, and there is no causal impression. If, however, B appears during A's approach, and A disappears during B's withdrawal (**exp. 6**), an impression of launching occurs as soon as the time-interval during which both objects are present reaches a certain size.

If the objects do not stand out so that they are distinct from each other, the Launching Effect tends to disappear. Thus if the subject is asked to alter his fixation-point (**exp. 7**), if he is separated from the objects by a ground-glass screen (**exp. 8**), or if he withdraws gradually from the apparatus (**exp. 9**), there is an impression of the continuous movement of one object passing over another ('Tunnel Effect'). If the objects are made very small (**exp. 10**), he has to go nearer to receive an impression of launching.

The conclusion in general is that two objects are necessary in order to segregate the two movements.

Chapter IV. The Polarising Influence of the Objects

1. THE RADIUS OF ACTION IN THE LAUNCHING EFFECT

In some launching experiments one is tempted to say, e.g., that 'B went too far' or that 'A came from too far'. This suggests that it is possible to determine the distance over which the launching action actually takes place. This distance will be called the 'radius of action' of object A or object B. In **exp. 11** adjustable shutters were added, and the subjects were required to determine the radius of action for each object. (For results see Table I, p. 55.) In **exp. 12** A's distance before the impact was varied. There was a Launching Effect as long as this distance was large enough to allow A to be seen to move towards B.

2. THE RADIUS OF ACTION IN THE APPROACH AND WITHDRAWAL EFFECTS

To apply the method of genetic analysis, it is necessary to analyse the Launching Effect into its main phases. In **exp. 13** A approaches B, which remains static. In **exp. 14** B withdraws from A, which had been in contact with it. Now as soon as A comes within a certain distance of B one receives the impression of approach, i.e. the movement of A becomes *polarised*, and B becomes its *centre of reference*. (When the movement is towards the centre of reference the polarisation will be

called *direct*; when the movement is away from the centre of reference, the polarisation will be called *inverse*.) The distance in question will again be called 'radius of action'. Table II, p. 61, shows the radius of action for the Approach and Withdrawal Effects.

3. THE LAUNCHING EFFECT AND THE APPROACH AND WITHDRAWAL EFFECTS

There are analogies between (*a*) launching and (*b*) approach and withdrawal as regards phenomenal character. For example, neither involves mere changes on a uniform background, and the concepts of centre of reference and polarisation, as well as that of radius of action, are applicable in both cases.

In launching there is a single operation with two aspects—an *impact-which-launches*. A's movement occurs first (i.e. there is a *hierarchy of priority* in time) and is therefore dominant.

What happens if A has an internal centre of reference? In exp. 15 A is a long rectangle, which expands towards B, after which B moves off. In exp. 16 A expands symmetrically, coming into contact with two objects B, one on the right and one on the left, which then move off. In these cases there is still an impression of launching even though A's centre of reference is internal. From this we may conclude that the polarisation of A's movement in the direction of B is not a necessary condition for the appearance of launching.

The question arises, however, as to whether this holds in the case of the inverse polarity of B's movement, and whether a causal impression occurs when approaches are followed by withdrawals in somewhat different conditions.

4. INVERSION OF POLARITY IN THE LAUNCHING EFFECT

(i) *The Tunnel Effect.* This involves the approach of A to a static object (the 'tunnel') and then its withdrawal on the other side. Experiments on the Tunnel Effect had varying results according to the length of time between the entry of the object into the tunnel and its exit. If the time is short the two movements are integrated in a single whole; if it is longer the movements are segregated and there can be inverse polarisation. In these conditions there is sometimes the impression that the object entering the tunnel has launched another object that was hidden there.

(ii) *Launching-in-flight.* In **exp. 17** A and B are both in movement; A comes up to B and halts, while B moves on much faster. When there is a large difference in speed there is an approach and therefore a Launching Effect, but where the difference is small one object is seen as moving behind the other.

There can still be an impression of launching even when B goes more slowly after the impact. This is paradoxical and runs counter to the laws of physics, since if an object is struck by another faster moving object of the same apparent mass we should expect the object itself to go faster!

In **exp. 18** A comes up to B, which is static; after the impact B moves off and A follows at a slower speed. The result again depends on their relative speeds: when the difference is large B is sometimes seen as withdrawing from A, and in these conditions there is an impression of launching; when the difference is small the Launching Effect gives way to the Entraining Effect. In **exp. 19** A and B are both in movement, A travelling faster before the impact and B travelling faster after the impact.

In general, the Launching Effect occurs if and only if the conditions are right for impressions of approach and withdrawal.

(iii) *Camouflage experiments.* In **exp. 20** B's movement becomes integrated with a spontaneous movement of five other squares to its right; and in this case there is no impression of launching. In **exp. 21** B performs to-and-fro movements before A's arrival; and again there is no launching unless one concentrates specifically on the point of impact. In **exp. 22** B is a long rectangle, which diminishes as A comes up; B's centre of reference is thus internal, and there is no impression of launching.

In **exp. 23** (the inverse of exp. 16) B is in the centre, and there are two A's, one on each side, moving inwards towards B; B then contracts symmetrically. Trained observers received no causal impression. In **exp. 24** A is on one side of B, and C on the other; both move towards B and finally change places. Here there are varying results, but no impression of launching. In **exp. 25** A withdraws after coming into contact with B while B moves off in the usual way. Again no impression of launching occurs. In **exp. 26**, however, where B goes to meet A and then returns, an impression of launching is obtained.

Expts. 17–26 confirm the view that if there is to be an impression of launching, B's movement must be inversely polarised.

A NOTE ON WEBER'S LAW (p. 70, note 16)

The normal formulation of Weber's law is $\frac{\Delta I}{I} = k$, *where* I *is the intensity of a stimulus and* ΔI *is the smallest increase in intensity necessary to produce a just noticeable difference. In this case* ΔI *is the smallest ratio of speeds necessary to produce a just noticeable launching. Michotte's point is that Weber's law does not entirely hold, since the same ratio gives 'better' launchings at slow speeds than at fast speeds.*

Chapter V. The Phenomenal Aspect of the Objects

Differences in the size of the objects and shape do not seriously affect the results, nor does their 'phenomenal character'. Thus there is still launching in **exp. 27** when through bad focusing the 'thing'-character of A and B is reduced. Similarly (**exp. 28**) there can be an impression of launching when A is a circle of light and B a wooden ball.

Chapter VI. Spatio-temporal Integration

The discussion so far has been concerned with the fact that the two movements are distinguished. It is now necessary to consider the conditions which make for their unification. They are conditions (*a*) of time, (*b*) of space, and (*c*) of speed; (*a*) and (*b*) are considered in this chapter, and (*c*) in Chapter VII.

1. TEMPORAL UNITY

Exp. 29. Varying time-intervals were introduced between the arrival of A and the departure of B. The three types of result were: (i) direct launching, (ii) delayed launching, and (iii) two movements. For detailed figures see Tables III and IV, and Fig. 5, pp. 92–94.

Exp. 30. B is suppressed; A goes to its usual place, and then moves on, after halting for different time-intervals. The results are given in Tables V and VI, and Fig. 6, pp. 97–99.

If there is to be an impression of launching, the temporal interval must be small enough to allow for the two movements to be unified in a single whole.

2. SPATIAL UNITY

(i) *Spatial contiguity.* **Exp. 31.** ('Action at a distance'.) A stops at varying distances before it reaches B. The result depends on the speed;

even when the gap is fairly wide (e.g. 50–70 mm.), there can still be an impression of launching if the speed is fast (e.g. 90 cm. per sec.).

Exp. 32. The edges of the slit are coloured, and B is thus in a corridor. This facilitates the impression of launching.

(ii) *The relative orientation of the movements.* **Exp. 33.** A moves in the usual way; B's path is parallel to but lower than that of A. In this case there is no launching, but an impression of triggering sometimes occurs. When the angular deviation of the paths increases (**expts. 34 and 35**) the Launching Effect is progressively weakened.

Exp. 36. A moves towards B and B suddenly jumps towards A. Here there is no causal impression, but some subjects compared the results to those which occur when iron filings move towards a magnet.

(iii) *The localisation of the movements in the same plane.* If A and B are seen by the observer to be in different planes (**exp. 37**), the causal impression disappears.

Chapter VII. The Speeds and the Hierarchisation of the Movements

1. THE COMMON SPEED OF THE OBJECTS AND THE CAUSAL IMPRESSION

Exp. 38. Both objects have the same speed. Speeds were used between 0·4 and 110 cm. per sec. Those of 20 to 40 cm. per sec. gave the best impression of launching. It would seem that speed acts as an integrating factor, and that for an impression of launching precisely the right amount of integration is called for.

2. THE RELATIVE SPEEDS AND THE CAUSAL IMPRESSION

It is possible to produce a hierarchy of speeds, which can be made either to reinforce or to weaken the hierarchy of priority.

Exp. 39. A travels at 40 cm. per sec. and B at 11 cm. per sec. In this case there is a 'better' Launching Effect than when the speeds are equal.

Exp. 40. If B's speed is greater (i.e. if there is an ascending as opposed to a descending ratio of speeds) there tends to be an impression of triggering. For details, see Table VII, p. 110.

It follows that the causal impression is better when the efficacy of the cause, as measured by the speed of the projectile, is *reduced*, and less good when this is *increased*. The goodness of the causal impression does not therefore depend on acquired knowledge.

Expts. 41 and 42. A comparison is made between ascending and descending ratios of speed, B's absolute speed being kept constant. In the case of **exp. 43** B's speed after the impact was the same as A's before it. The main conclusion is that ascending ratios tend to give an impression of triggering, and descending ratios to give an impression of launching. The *ratio* of the speeds is thus the determining factor.

3. THE RELATIVE SPEEDS AND INTEGRATION

If the ratio of speeds affects integration, one would expect an impression of 'delayed launching' and of 'two movements' to occur when there are relatively smaller time-intervals in the case of an ascending ratio than in the case of a descending ratio. Tables VIII and IX, pp. 114–115, show the results (i) when exp. 39 (descending ratio) was used, and (ii) when exp. 40 (ascending ratio) was used. The same three subjects took part in each case, and the results can be compared with those of Tables III and IV (when the speeds were equal). Here the conclusion is that an ascending ratio acts as a factor of segregation.

Does this hold in the case of the movements of a single object? **Exp.** 44 (descending ratio) and **exp.** 45 (ascending ratio) confirm that it does. For the results of exp. 44 see Tables X and XI, pp. 116–117, and for results of exp. 45 see Tables XII and XIII, pp. 118–119.

4. THE HIERARCHY OF THE MOVEMENTS AND THE LAUNCHING AND TRIGGERING EFFECTS

The difference between launching and triggering is not fully accounted for simply in terms of the segregation which occurs when there is an ascending ratio of speeds. The Triggering Effect would seem to be a compromise impression, arising from a conflict between the hierarchy of priority and the hierarchy of speeds. The essential feature in the Triggering Effect is that the movement of B is autonomous without being spontaneous.

Chapter VIII. The Launching Effect Seen as a Whole

1. THE CASE OF THE LAUNCHING EFFECT

Observers tell us that 'it is the blow ("choc") dealt by A which drives away B'; in other words there is an impact-which-launches ('choc-qui-lance'). This implies (i) that the movement is continuous, and (ii) that it belongs to object A. How can both these propositions be true?

As a parallel one can cite cases of phenomenal metamorphosis (e.g.

changes of shape in clouds or cigarette smoke). Thus (exp. 46) if object A is a curve and object B a straight line, and if A is abruptly replaced by B, observers report that it is the curve which becomes straight.

Similarly the Launching Effect is a single process (compare the use of the term 'world-line' by Duncker and Metzger); the pushing away is a continuation of the impact. There is a phenomenal *becoming*.

This implies that the withdrawal movement must be considered as belonging to A, not B. B undergoes merely a 'displacement' (i.e. change of position); there is a phenomenal duplication, i.e. B's (physical) movement appears both as a movement, belonging to A, and as a displacement, belonging to B. If a spot of light (A) approaches a circle (B) and then stops (exp. 47), it is possible to have the impression that A *passes behind* B; this example illustrates that there can be apparent continuation of an object's movement even when that object has ceased to exist.

In the case of launching, the movement of the motor object appears to extend on to the projectile, which then undergoes a displacement. This situation will be called 'ampliation of the movement'.

2. THE CASE OF THE TRIGGERING EFFECT

Like the Launching Effect the Triggering Effect is a form of link between two movements, but in this case ampliation is cut short.

A NOTE ON AMPLIATION OF THE MOVEMENT

One of the central difficulties which Michotte discusses in this connexion is the idea that a movement can still belong to object A even though it is object B which is being 'displaced'. When there is a different object performing the movement, does not this entail as a matter of logic that it cannot be the same movement? Michotte in reply proposes an extension of the idea of 'permanent matter' so that it can apply to, e.g., sounds and movements. Expressed differently, his point is that, for the occurrence of the causal impression, the stimulus-conditions must be such that, if per impossible *only one object were involved, one would say that there was continuous movement of this object; what happens is comparable to a continuous movement except that the two objects are necessary as agents of segregation and polarisation.*

[1] *Since the second French edition of this book* (1954), *new experiments have led Michotte to simplify the theory of ampliation of the movement in the way described in Appendix II.*

Part Two—The Entraining Effect

Chapter IX. The Structural Organisation of the Entraining Effect

1. THE ENTRAINING EFFECT AND THE LAUNCHING EFFECT

The Entraining Effect is structurally very similar to the Launching Effect; in particular the movement throughout belongs to A, and B undergoes merely a displacement.

What happens, then, if the attempt is made to give B an autonomous movement? In exp. 48 both A and B are in motion at the start, A moving faster. After the impact both travel at B's speed. **Exp. 49** is the same as exp. 48 except that after the impact both travel at A's speed.

In the case of exp. 48 the result depends on the point of fixation. Thus if the observer fixates B, there is no Approach Effect and hence no impression of entraining. In the case of exp. 49 there is an impression of entraining provided the difference in B's speed before and after the impact is large enough.

2. THE ENTRAINING EFFECT AND THE TRANSPORT EFFECT

In the case of the Transport Effect (when one object is transported on another) there is a single movement, that of the transporting object.

Exp. 50. One object is a white screen, the other a disc 5 mm. in front of it, and both perform a simultaneous horizontal movement. There is no Transport Effect here, but a single object is seen in motion, the disc appearing as part of the surface of the screen. To achieve the Transport Effect, it is necessary to ensure a distinction between the two objects. In **exp. 51** the disc does a few short vertical oscillations, and this is sufficient to achieve the required distinction. There is no causal impression, however, even though the transporting object is physically the cause of the movement of the transported object.

Exp. 52 is the same as expts. 50 and 51 except that the movement of the screen begins first. In this case the screen appears to entrain the disc; and it would seem to follow that the temporal priority of the transporting object is the decisive factor in making the difference. After the objects have moved a short distance the Entraining Effect gives way to the Transport Effect. The causal impresion is thus limited to the period during which ampliation of the movement is taking place,

changes of shape in clouds or cigarette smoke). Thus (**exp. 46**) if object A is a curve and object B a straight line, and if A is abruptly replaced by B, observers report that it is the curve which becomes straight.

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movement. Michotte's point is this. If one considers the Launching Effect only, it might seem as though this priority is necessary merely to ensure the requisite 'phenomenal duplication' (i.e. that the physical movement of B should be perceived both *as belonging to A* and *as being a displacement of B). But there can be similar duplication and belonging in the case of the pure Transport Effect, without there being a causal impression. It follows that this priority is necessary for some other reason. This reason is connected with the theory of ampliation of the movement; there must be a pre-existing movement which at the moment of impact becomes extended on to object B.*

Michotte then goes on to point out that this temporal priority has a segregative influence, and he indicates a method of measuring the distance for which the segregation lasts.

Chapter X. Launching-by-Expulsion

Launching-by-expulsion occurs e.g. when someone throws a stone or shoots with a bow and arrow. It differs from launching-by-striking in that there is a Transport Effect at the start instead of approach-impact.

Exp. 59. A and B are joined together; after they have travelled some distance A stops and B continues to move. In this case there is no causal impression, since to produce one it is necessary for the two objects to remain distinct during the first phase. This can be achieved (**exp. 60**) if A moves up to B first; A is then seen to launch B after having entrained it for some distance.

Sometimes the projectile is not visible, e.g. when a person throws a stone that had been hidden in his hand. In **exp. 61** A alone is present, and when it has moved to its usual place B appears in motion beside it; in these conditions there is sometimes an impression of launching.

Exp. 62. This involves experiments with a comparison-tachistoscope. The designs used (see Fig. 7) involve a schematic representation of javelin-throwing (designs A, B, and C) and of shooting with a bow and arrow (designs D, E, and F). A causal impression was found to occur on some occasions.

Chapter XI. Propulsion

In the bow and arrow, harpoon, and javelin examples it seems certain that there is a causal impression at the very start of the operation, before the two objects separate. This is confirmed by **exp. 63**, where

and this shows the affinity of the Entraining Effect with the Launching Effect.

The result of the priority of A's movement is not simply to create the Entraining Effect in place of the Transport Effect; it has also a segregative influence, as in expts. 50 and 2 where there is no Transport Effect in any case. The limits of this influence can be determined if the subject is asked to determine how soon the Entraining Effect gives place to the impression of a single rectangle in movement (**exp. 53**); the results for different speeds are given in the table on p. 155.

It is interesting to compare expts. 48 and 49. Since observers receive an impression of entraining in exp. 49 when both objects have A's speed, why do they not receive an impression of traction when both objects have B's speed (exp. 48)? If the encounter produces an acceleration of B's movement in exp. 49, why does it not have a braking effect on A's movement in exp. 48? To enable this to happen, B would have to be the centre of reference for A's movement after the impact; but this is impossible, since A's movement has become dominant on account of its faster speed.

3. THE RELATIVE SPEEDS AND THE ENTRAINING EFFECT

The results of **exp. 54** show that for a descending ratio of speeds the Entraining Effect becomes something like a 'push'; for an ascending ratio odd comparisons are used, e.g. A 'tiptoeing' up to B. There can be entraining (**exp. 55**) if both objects are in motion at the start (with A moving faster) and the common speed after the impact is less than B's speed before it. This again is paradoxical, since B is being causally acted upon by a faster body and yet goes slower as a result.

4. THE TRACTION EFFECT

The Traction effect can be produced if A goes past B and they both move on together (**exp. 56**), or if A is on B's right and moves some distance before B starts (**exp. 57**). If A goes up to B and then they both move leftwards (**exp. 58**), there is a Traction Effect only at high speeds. The Traction Effect is a special case of the Entraining Effect.

NOTES ON CHAPTER IX

The logic of the argument on pp. 154 and 155 is complicated. The main issue is to determine what part is played by the priority of A's

where the 'caterpillar' situation occurs with one lengthening and one shortening only. When the experiment is carried out at a slow speed most observers report only a dilatation-contraction (phenomenal disappearance of forward movement), and when it is carried out at a fast speed most of them report only a forward movement (phenomenal disappearance of change in shape). Since on the present hypothesis both factors are necessary for the impression of animal locomotion, one would expect few or no reports of it in these conditions, as was in fact the case. Segregation of change in shape and forward movement can also be achieved (**exp. 69**) by making the latter appreciably faster than the former.

In auto-locomotion *what was* change in shape *becomes also* forward movement; there is thus a continuous ampliation, similar in some respects to that which occurs in the case of propulsion.

If H and T no longer belong to the same object (**exp. 70**), all impression of auto-locomotion disappears.

There are analogous movements in inanimate nature (e.g. the movements of clouds and waves); it is therefore not surprising that primitive people and children should regard such things as alive.

It may be that the 'internal flux' (movement of small particles) in the case of the caterpillar can be thought of as the cause of its change in shape, in a way analogous to propulsion type II. The unity of the object acts against any phenomenal separation of cause and effect, but there is a general character of productivity which 'invites' us to use causal terminology in this case. (This, of course, assumes that our idea of cause comes originally from elsewhere.)

NOTES ON CHAPTER XII

Michotte argues in this chapter that in the case of animal locomotion the animal appears in some sense to be the source of its own movement, and he is therefore concerned to show that the theory of ampliation of the movement will cover cases of this kind. A further point of crucial importance emerges from the discussion, viz. that movements of living objects are visually *different from those of inanimate objects. From this it follows, as Michotte points out, that animism, i.e. the attributing of life to clouds, smoke, etc., does not presuppose any mysterious act of 'projection' on our part, but arises because of similarities in visual appearance between clouds and smoke on the one hand and moving animals on the other.*

The following points may serve to clarify the details of exp. 69.

designs were used (see Fig. 8) similar to those of exp. 62 except that the second of each pair showed the two objects still conjoined. This form of causality will be called 'propulsion'.

Now in these cases the two movements begin simultaneously; and at first glance it is puzzling that a causal impression should occur at all, since according to the theory the temporal priority of the movement of the motor object is essential for its appearance. What is involved in this case is an ampliation which is continually being renewed during the change in shape of the motor object.

When the change in shape of an object produces the forward movement of another object, this will be called 'propulsion type I'; when a change in shape or a forward movement produces a change in shape, this will be called 'propulsion type II'.

Exp. 64. A is made to look rhombus-shaped when in motion, and B is a static rectangle which becomes rhombus-shaped as it moves off after A's approach. The result is that A appears to change B's shape (propulsion type II), even though B's centre of reference is internal. Its change in shape is autonomous while dependent on the movement of A for its beginning, and this case is thus analogous to that of the Triggering Effect.

Chapter XII. Animal Locomotion

Movements performed by men and animals have a special character; the moving object appears as the source of its own movement.

In **exp. 65** a single object, 10 mm. long, is present, which dilates to the right until the head-end (H) has moved 32 mm., and then contracts from the left until the tail-end (T) is again 10 mm. from H. This is repeated several times. **Exp. 66** is the same as exp. 65, except that H and T move at different speeds from each other. The result in both cases is the appearance of live movement—that of a caterpillar or a worm. We can compare this result with propulsion type I, where again there is both change in shape and forward movement.

Exp. 67. In the first phase the object dilates symmetrically; in the second H moves slowly to the right while T changes direction and moves to the right also. In these conditions there is an impression of swimming, as performed e.g. by a frog.

If there is to be an impression of animal locomotion there must be (i) dilatation-contraction, and (ii) forward movement of the whole. These two factors must now be studied in isolation. This is done in exp. 68,

then moves off. The result in these conditions is at most a Triggering Effect. If the caterpillar reaches B in the *middle* of its third 'step', however (**exp. 72**), there is a greater overall unity and a clear Entraining Effect (sometimes, indeed, a Launching Effect).

In the case of voluntary action the 'I' takes the place of the body-object, which becomes phenomenally effaced; there is an impression of immanent activity (whether auto-motor or causal), and this activity has the special character of being 'mine'. As far as the causal impression is concerned, there is the same structural organisation as in the visual sphere, and the theory of ampliation of the movement is still applicable.

NOTES ON CHAPTER XIII

The main purpose of this chapter is to show that there can be causal impressions in the tactile-kinaesthetic sphere and that the same structural properties are involved as in the case of visual impressions of causality. Despite its difficulty and certain obscurities, it contains many suggestive and fascinating points. Among these may be mentioned:

(1) *'The spatial character of the sense of touch' (footnote p. 201). This point is fundamental, since there could be no analogies between vision and touch without a common spatial framework. An interesting contrast is the case of hearing. Sounds can be arranged serially in loudness and pitch (compare the relative lack of serial character in the case of taste and smell), but, unlike visual objects, they are not laid out in space in such a way that one can survey them simultaneously. (An attempt to produce a causal impression by means of an 'approach' and 'withdrawal' in pitch was in fact unsuccessful; see exp. 89.) This footnote raises the whole question of the serial or linear character of different sense-modalities.*

(2) *The discussion of our awareness of our own body. Though Michotte does not use the phrase, he is in effect talking about what many psychologists have called the body-image or body-schema; and many of his points, e.g. his reference to the absence of figure-ground distinction from the kinaesthetic point of view, are valuable contributions to this fascinating subject. Examination of the logical behaviour of the word 'I' is of particular interest in this connexion. Thus Ryle*[1] *has pointed out that it makes sense to say 'I was not scorched; only my hair was', but not 'I was not scorched; only my face and hands were'. This is in effect to say that a person's face and hands lie within his body-schema in a way in which his hair does not. It is*

[1] G. RYLE, *The Concept of Mind*, Hutchinson, 1949, p. 189.

(*a*) *The speed of the object's forward movement will be half-way between the speed of H and that of T, viz.* 3·6 *cm. per sec.* (*or, in the variation of the experiment,* 7·2 *cm. per sec.*).

(*b*) *The speed of dilatation in the first phase and contraction in the second is the difference between* 4·32 *and* 2·88, *viz.* 1·44 *cm. per sec.* (*or* 0·72—*strictly* 0·71—*cm. per sec. in the variation*).

Thus the speed of the forward movement (3·6) *is* 2·5 *times as great as that of the dilatation-contraction* ($2{\cdot}5 \times 1{\cdot}44 = 3{\cdot}6$). (*In the variation the ratio is* 10 : 1, *i.e.* 7·2 *and* 0·72.)

Chapter XIII. Tactile-kinaesthetic Perception of Mechanical Causality

There is no doubt that there can be causal impressions in the tactile-kinaesthetic sphere.

Our own body, viewed kinaesthetically, has certain peculiarities as compared with the objects which we can see and touch. For example, it appears as *my* body, and, unlike visual objects, which stand out as 'figures' on a 'ground', it occupies the whole of the kinaesthetic field. In spite of these peculiarities, however, it is in some ways 'thing'-like; and, with reservations, we may compare it to a kind of kinaesthetic amoeba with its parts in flux. There is comparatively little demarcation between the parts, but they can undergo changes in shape, and if one part is in movement relative to a second, the second can take on the rôle of 'external' centre of reference for the first. The situation is thus comparable to those described in Chapter XII; there is an overall character of productivity, and the body appears as the *source* of the movements which it performs.

When the body acts on external objects, clear causal impressions can sometimes be obtained. Thus when a limb undergoing a passive movement comes into contact with, e.g., a ball, one can have the impression that the limb launches or entrains the ball; when a person is holding a stick and an assistant moves the stick horizontally, the person can have the impression that his arm is being entrained by the stick; and when the patellar reflex is touched off and an object is put near his foot, he can sometimes have the impression that his foot launches or entrains the object. An internal centre of reference, however, weakens the causal impression—a point which is confirmed by the following experiment.

Exp. 71. This is the caterpillar experiment, with a motionless object on the right; after three 'steps' the caterpillar reaches this object, which

ceive a causal impression when mechanical work is being done, just as we receive an impression of movement when movement is actually taking place.

NOTES ON CHAPTER XIV

The discussion (pp. 225–226) as to whether the causal impression is 'objective' is in effect a conceptual one. According to Michotte's proposed criterion of objectivity, it is objective whenever corresponding physical work is being done.

The philosophical colleague mentioned on p. 228 is in effect using a version of Wittgenstein's 'polar principle'; the very fact that we can regard these experiments as producing illusions *of causality implies that, sometimes at least, we are confronted with the genuine article.*

QUALITATIVE CAUSALITY

Chapter XV. Movement of One Object linked with Qualitative Change in Another

In some causal transactions there is the appearance or disappearance of an object or a qualitative change. Cases of this kind will be referred to as instances of 'qualitative causality'.

Exp. 73. B alone is present; A appears beside it, and B immediately moves off. In this case most subjects reported a launching.

In **exp. 74** A and B are 5 or 6 cm. apart. A moves towards B, which abruptly disappears, or (**exp. 75**) changes colour. In these cases some but not all subjects reported launching. The impression of launching, however, appears to be due to the presence of gamma movements; and there is therefore no evidence here for the existence of genuine impressions of qualitative causality. To test this hypothesis, the gamma movements can be so arranged that they take the place of objective movements in circumstances where on the theory of ampliation of the movement one would not expect a causal impression. When this was done (**expts. 76, 77, 78, and 79**) there were scarcely any reports of any causal impression.

Exp. 80. Various changes in the object were accompanied by noise. Despite the reports of a few subjects, it is doubtful if there is a genuine causal impression in these cases.

Expts. 81 and 82. Noise was introduced at the moment of impact.

clear that in determining the limits of our body-schema we are influenced in large measure by the area which we are able to control.

(3) *The discussion of voluntary action. Michotte's main point here is that the ego or self takes the place of the body and plays a part analogous to that of object A in experiments of launching and entraining; on this basis he is able to claim that our own experience of causing things to happen can be accounted for in terms of his general theory. Moreover, it follows that we are not simply being superstitious or anthropomorphic in supposing that, when external objects strike one another, a structurally similar situation is taking place. For a discussion of the legitimacy of retaining the concept of the 'ego' in psychology, see K. Koffka,* Gestalt Psychology, *Harcourt Brace & Co., New York, 1935, pp. 319 seq.*

General Conclusions

Chapter XIV. Ampliation of the Movement

On the basis of the experiments so far described, causal impressions may be classified into two groups, viz. (*a*) launching, including triggering, and (*b*) entraining, propulsion, and auto-locomotion. All alike involve ampliation of the movement.

From the definition of ampliation it follows that launching and entraining are the only types of causal impression which are theoretically possible. Ampliation also explains the negative and paradoxical cases, and in addition it enables us to understand the productive character of the causal impression.

The objection may be raised that the causal impression is a purely subjective creation occurring when certain movements are combined, and that the passing of movement from one object to another is not something which can be detected by instruments. The reply to this is that detectability by instruments is not a criterion of objectivity; instruments detect only proximal stimuli[2] (light waves, etc.), which are less like the objective physical world than is the phenomenal world. It is, of course, perfectly possible to produce illusions, but in the normal way our perceptions of causality are reliable. Despite the negative and paradoxical cases mentioned above, the phenomenal world corresponds in many important ways with the physical world; and usually we re-

[2] For an account of the distinction between proximal and distant stimuli, see K. KOFFKA, op. cit., p. 80.

performed experiments such as ours, he would no doubt have attributed the origin of the popular idea of causality to the causal impression and not to habit and expectation; but it is probable that his philosophical position would not have been affected at all.

Since it has been shown that there is a causal impression only in the case of *mechanical* causality, the problem raised by Hume must still arise in cases of *qualitative* causality; why in such cases is the notion of causality so frequently used? It would seem that in some cases there must be inference, as e.g. when we infer that the sowing of seeds caused the appearance of a crop; in the case of the impact-noise experiments the qualitative event becomes integrated in an experience of causality of activity—a situation which occurs in all sorts of occasions in ordinary life.

Hume also raised the question of why the effect is thought of as *necessarily* following from the cause. Claparède pointed out, in criticism of Hume, that a child can learn that a cat claws or that a fire burns without having to have the experience several times over. In the present experiments the subjects said that they could see no necessity that object A should drive off or carry off object B; but there is surely a phenomenal necessity, in the sense that B's departure is imposed on it by A. The situation is analogous to those cited by Wertheimer, Köhler, Duncker, and others, in which a process 'requires' to be completed in a certain way.

The basic form of the causal impression is the Entraining Effect; the Launching Effect is a modified form of the Entraining Effect, in which the motor object stops at the moment of impact.

2. MAINE DE BIRAN'S THEORY

Since the present research has shown that there can be causal impressions in external experience, it follows that internal experience cannot at any rate be the only source of the idea of cause.

Maine de Biran's 'primary fact' corresponds in effect to what we have called voluntary movement 'in the air'. Such movements have the character of 'immanence'—a character which also occurs in the case of reflex activity. Now where there is immanent activity, whether our own or that which occurs in animal locomotion, there is a vague character of 'productivity', even though not the clear-cut character of causality which occurs in the case of launching and entraining. Once one has acquired the idea of causality, however, one can apply it to cases of

A number of subjects, after suggestion, indicated that the impact produced the noise. But there is no evolution here, and one must suppose that the noise is a property of the visual event; the impression of noise becomes integrated with the impression of activity, so that it is a 'noisy' or 'noise-making' activity.

Chapter XVI. The Linking of Qualitative Changes in Two Objects

The experiments described in this chapter involved no objective changes in position. In exp. 83 A and B appear (or disappear) in quick succession, and there is no causal impression; this result confirms what has been said with regard to gamma movements.

In exp. 84 B is present, motionless; A appears beside it and B disappears. One might have expected a launching here, but instead there is a stroboscopic effect; B simply appears to change its position.

Exp. 85. A is a green circle, B a red one. A becomes yellow (or red), B blue (or green). Here again there is no causal impression. Similarly (exp. 86) there is no causal impression when circle B is placed inside circle A and both circles change colour. Temporal and spatial contiguity is insufficient to produce a causal impression. Experiments with shades of colour (expts. 87 and 88) produced negative results, as also did an experiment with the 'approach' and 'withdrawal' in pitch of two sounds (exp. 89). An experiment with a triangular and circular spot of light (exp. 90) produced no causal impression either.

There is no possibility for ampliation of the movement to occur in these cases, and the conclusion is that there is a causal impression only in the case of mechanical causality, not in the case of qualitative causality.

THE ORIGIN OF THE IDEA OF CAUSALITY

Chapter XVII. Critical Reflections on Different Theories

1. HUME'S THEORY

Hume did not believe in the existence of the causal impression, only in the existence of isolated successive events. It must be supposed that he continually adopted an analytical attitude; and it is necessary to remember that he never took part in any systematic research. Had he

4. THE APPARENT 'SOURCES' OF THE EMOTIONS

On the phenomenal plane emotions appear to be brought about by events. Is there really a causal impression here?

The very word 'emotion' implies 'movement of the soul', and there are numerous idioms suggesting the connexion between emotions and movements. In some cases emotions are undoubtedly preceded by movements, e.g. the fear that arises from the movement of someone's fist towards us; but this is not universal, and the relations between emotions and the events from which they are derived are of many different kinds.

APPENDIX I

A SPECIAL CASE OF PROPULSION. THE TRACE-MAKING EFFECT

If an object leaves a trace or mark behind it, or conversely if it erases an existing mark, this implies the creation or destruction of matter. The presence of a causal impression in these cases seems at first glance to be incompatible with the theory of ampliation of the movement, and further investigation is thus necessary.

I. THE CAUSAL TRACE EFFECT

Exp. 91. Object A moves towards the right, and, after it has moved 3 cm., a black strip, object B, appears on its left, and expands towards the right at the same speed as that of object A. The usual result is that A appears to be writing, or, if the experiment is done in reverse, to be erasing.

What are the special characteristics of the causal impression of trace-making?

(i) In all our other experiments A and B were both 'figures' separate from their background; in this experiment B is simply a background mark. Since B can still have this character in the case of the Screen Effect (see exp. 94), it follows that the causal character of the experience of trace-making is not responsible for this; on the contrary, it is the result of the kinematic properties of the stimulus-conditions, which involve the appearance of B immediately behind A and its lengthening *pari passu* with A's advance.

immanent activity, and indeed the notion of vague productivity may occur earlier in the child's life than that of causality; what one cannot say is that the idea of causality is *derived from* the idea of immanent activity. Maine de Biran's mistake was to confuse the two.

Moreover, why *should* the idea of immanent activity be applied to external objects? Maine de Biran's theory of an 'initial induction' suggests something superimposed on what is given phenomenally, and this is incompatible with the findings of this book. Lipps' theory of projection as a result of empathy might seem to provide an answer, but is open to the following objections: (i) It is unnecessary, since the occurrence of causal impressions in external experience makes any other hypothesis superfluous. (ii) Why should this projection occur only in certain conditions of speed, orientation, etc.? (iii) If projection occurs in the case of *voluntary* motor activity, why do we not have the impression that A is voluntarily driving away B? (iv) Since Maine de Biran's 'primary fact' is an impression of activity and not of causality, how could the visual event receive a character of causality when such character was not even present in the original impression of activity? It seems more likely that when empathy occurs, this is because visual experiences of causality, being similar in structure to causal experiences in the tactile-kinaesthetic field, evoke movements of the muscles such as we ourselves would perform if we were performing the operations in question.

3. THE WORK OF PIAGET

Piaget has pointed out that in the very early years there is no segregation between the 'cause-movement' and the 'effect-movement'; to use the present terminology, the child has impressions of immanent motor activity. There is no distinction between 'self' and 'not-self' and not necessarily any awareness of the permanence of objects.

What Piaget calls 'phenomenalism' (i.e. the assumption that any two separate events can be causally connected) arises, it seems, from defective powers of segregation in the child. 'Artificialism' (i.e. the tendency to attribute external events to his own activity) can be explained by an excess of integration, and animism (i.e. attributing life to clouds, smoke, etc.) by lack of differentiation. It is an important methodological point that if a child at a certain age shows a particular sort of behaviour, it is still perfectly possible that some of the ideas involved in that behaviour were acquired at an earlier stage.

involves a *movement* of B, even though this movement is limited to A's immediate edge; (iv) the Emanation Effect is very similar to the Screen Effect, but the situation is complicated by the fact that the two objects are in the relation of container to content.

When an object 'comes out of' a container, this object is usually dominant because of its state of movement. If the container is in movement, however, as in the Emanation Trace Effect (exp. 91, with increased length of B), a different kind of hierarchy is set up, with A's movement the dominant one.

In the Causal Trace Effect A is actively depositing colour, but as soon as the impression of B's lengthening (relative to its starting-point) is destroyed, the result is the Emanation Trace Effect—a mere leaving of a trace, with no causal impression. The evolution in this case is suggestive of that mentioned in Chapter IX, where there is a substitution of the Transport Effect for the causal impression of entraining.

APPENDIX II

THEORY OF PHENOMENAL CAUSALITY NEW PERSPECTIVES

1. GENERAL CONSIDERATIONS ON METHOD

The phenomenological method may be explained as follows: the experimenter has at his disposal two sources of information, (*a*) that constituting the stimulus-system and definable in physical units such as centimetres or seconds, (*b*) the verbal responses of the subject, on the basis of which one may form hypotheses about the properties of the structure of what he perceives.

The research on perceived causality may logically be divided into seven stages.

Stage I. This involves the investigation of what are the simplest experimental conditions in which causal responses occur.

Stage II. This comprises the study of 'concomitant variations' between changes in the stimulus-conditions and changes in the subjects' verbal responses.

Stage III. Investigations under Stage II point to the conclusion that there is often a specific difference in perceptual structure when causal

(ii) B's movement of lengthening participates in A's movement, and A's movement, since it appears first, is dominant. Hence the conditions for ampliation of the movement are satisfied after all. If B does not lengthen, but is a vertical line 1 mm. wide, without movement (**exp. 92**), any causal impression disappears. There is thus no causal impression of *creation* of matter as such.

(iii) There is a difference between lengthening (which is genetically related to unfolding) and dilatation, since in the latter case, too, the quantity of matter remains the same. In **exp. 93** A and B are both present; A moves towards B and passes over it, and B then lengthens, remaining attached to A. The result is an impression of stretching, not an impression that matter is being added. If A starts to leave a trace the moment it is in motion (**exp. 94**), the result is often the Screen Effect, i.e. the impression that A uncovers B.

(iv) In spite of this difference, there are similarities between lengthening and dilatation; in particular both involve an internal centre of reference. It may be surmised that, just as one object can be centre of reference for another only within the limits of the radius of action, so there can be no impression of lengthening outside certain limits of distance.

(v) In the Causal Trace Effect there is *addition* of matter; A is *doing* something, viz. depositing matter on the background, and this is something more than a mere emanation.

2. THE EMANATION TRACE EFFECT

When the trace exceeds a certain length (see iv, above), there is no longer a causal impression; instead there is the Emanation Trace Effect. The next requirement is to study the phenomenon of emanation in more detail.

Exp. 95. Object A is a trapezium which moves towards the right; after it has travelled 3 or 4 cm. a red strip appears in contact with it and expanding towards the right at the same speed. The results are variable, but in many cases, particularly if subjects fixate the rear end of the trapezium, B appears to emanate from A, although it does not in this case have the character of being a trace.

The following are the principal properties of the Emanation Effect as it occurs in this experiment: (i) there is no impression of lengthening in the strict sense; (ii) there is an immobilisation of B's matter after it has come out of A; (iii) the impression of 'coming out of', however,

(i) *The distinction between movement and displacement. Stage IV.* As a preliminary to what follows a distinction requires to be made between 'movement' and 'displacement' (compare pp. 134–135).

(ii) *Theory of the Entraining Effect.* The Entraining Effect comprises three phases. In the first there are two objects, one moving towards the other; in the third there is a total configuration comprising a bi-coloured rectangle. It is the events of the second phase which give rise to causal responses.

Stage V is the analysis of the structure mentioned in Stage III, with special reference to the second phase. When object B starts to move at the same speed and in the same direction as object A, the conditions are right for the operation of the principle of 'common fate'. Although for the moment the two objects are distinct, the movement belongs to A; thus it is A *in movement which seems to be displacing B, and this* accounts for the *productive character of the impression received. The segregation of the first phase is maintained during the second; but there* is a single movement which, by the process of phenomenal duplication, appears both as a movement of A and as a displacement of B.

Stage VI. This is concerned with the relationship between the structure just analysed and the stimulus-conditions. When 'common fate' operates the amount of similarity can vary; thus there is optimal similarity if A slides behind B and they move conjointly (Fig. 9, p. 322). In the 'pliers' experiment (**exp. 96**, Fig. 10, p. 323) there is again considerable similarity because of the amount of common movement, and a spectacular Entraining Effect is obtained. Where there is no contact between the objects, however, as in Thinès' experiment (Fig. 11, p. 323) when A is made up of three dots in a triangular shape and B is a single dot, the structure of entraining is much less assured. Again Crabbé found that the number of 'traction' responses (a special form of entraining) increased when the common path of the objects was longer (Fig. 12, p. 325). In 'amodal' entraining (in which there is an impression of entraining when A covers B and they apparently go on together, as in Fig. 13, p. 325), B still shares A's 'fate' since for a certain time it is present 'amodally' behind A.

During the first phase the objects are clearly distinct; this character lasts during the second phase and is a manifestation of phenomenal permanence. This permanence is illustrated by **exp. 97** (Fig. 14, p. 327) where A and B move together from opposite sides of the slit and each

responses are given as compared with occasions when subjects report 'two movements'.

NOTES ON MICHOTTE'S REVISED THEORY

From this point onwards the exposition of the logical 'stages' in the argument is given pari passu *with an account of the revised theory of perceived mechanical causality.*

The main points in the revised theory are:

(*a*) *The concepts of 'polarisation', 'apprcach', and 'withdrawal', though applicable in special cases, are no longer regarded as essential to the theory. Instead the emphasis is on the phenomenal permanence of the contrasting 'states' in the first phase (A moving, B at rest).*

(*b*) *Ampliation of the movement is shown to depend both on this permanence and on the occurrence of kinematic integration at the third phase. Kinematic integration is due in the case of entraining to the operation of 'common fate' (since A's movement after the impact has the same speed and direction as B's displacement) and in the case of launching to the operation of 'good continuation' (since B's displacement after the impact is in the same direction as A's movement before the impact). A conflict situation arises between the permanence of the contrast between the 'states' in the first phase and the factors making for kinematic integration; and the resolution of this conflict situation takes the form of a phenomenal duplication as a result of which one and the same movement appears both as a movement of A and as a displacement of B. The causal character of the impression is accounted for by the fact that it is the moving A which brings about B's displacement.*

(*c*) *The radius of action can now be understood as the duration of time for which the influence of permanence is operative.*

(*d*) *In the case of the Triggering Effect B's movement is now thought of as 'dependent on' that of A, but triggering is no longer thought of as a weakened form of launching.*

2. THEORY OF PERCEIVED MECHANICAL CAUSALITY

This section is subdivided into three main headings. (i) The first gives an account of the distinction between 'movement' and 'displacement'; (ii) the second contains the revised theory of the Entraining Effect, and (iii) the third the revised theory of the Launching Effect.

when B appears and there is no conflict. In each case no causal influence was reported, and the original hypothesis is thus again confirmed.

(iii) *Theory of the Launching Effect.* As in the case of the Entraining Effect there is a conflict situation. This time it is between (*a*) the tendency to permanence of the kinematic states in the first phase (A in motion, B at rest) and (*b*) the effects of the stimulus-system operating in the second phase (A at rest, B in motion). As a result of 'good continuation' there is still phenomenally one and the same movement.

The camouflage experiments (pp. 72 seq.) are compatible both with the old and new theory; and the occurrence of launching at a distance is not incompatible with the new theory, since neither in static nor in kinematic configurations is complete continuity necessary for integration.

3. GENERAL CONCLUSION AND DISCUSSION

The views put forward in this book coincide with those of Piaget in many respects, but a comparison also reveals some divergencies.

4. 'CAUSE', 'CONDITION', AND 'DEPENDENCE'

In ordinary life it would seem that one often meets situations which require description in causal terms but where there is no ampliation; and since the discussion in Chapter XVII of this book new data have been collected.

Levelt, for instance, has reported responses of 'braking' in appropriate conditions. These, however, appear to be the result of acquired knowledge; there was no mention of any immediate 'causal impression'.

In exp. 102 (Fig. 22, p. 363), A moves towards B and goes beyond it, and B then moves in the opposite direction. A few causal responses were obtained, as in a similar experiment by Metelli; and Metelli and others have reported causal responses when the proximal stimuli corresponded to a situation of 'attraction'. Although there is no ampliation here, the conditions are not unlike those which give rise to the Triggering Effect. These cases thus involve 'phenomenal dependence'; the antecedent is a *condition* for the operation of the cause.

'Phenomenal dependence' may also be operative in cases of launching and entraining. The detailed conditions in which it occurs require further investigation.

then returns to its starting-point; a contact of at least 300 milliseconds is required if the impression of a single rectangle is to arise. There is also permanence of movement as is shown by **exp. 98** (Fig. 15, p. 329), an experiment in which two slanting parallelograms come together and then move off. Even when A and B are similar in colour and conditions similar to those of ordinary entraining are produced (**exp. 99**, Fig. 16, p. 331), the objects tend to remain distinct. In all these experiments the tendency towards permanence is in conflict with the operation of 'common fate'. In the Entraining Effect the solution of the conflict takes the form of phenomenal duplication; this is comparable to the conflict in static situations, e.g. when a triangle and a square have part of a side in common (as in Fig. 17, p. 335).

Stage VII. This involves a counterchecking of the hypothesis already formed. If the structure of entraining involves a conflict between the tendency towards permanence and the operation of 'common fate', then when either is strengthened or weakened in relation to the other we should expect fewer entraining responses. This is in fact what we find.

(*a*) Segregation strengthened. (i) In an experiment by Thinès (Fig. 18), A was three circles of light and B one circle, both A and B being on the boundary of a rectangle. The presence of gamma movements and the presence of the rectangle combined to give B its own movement, thus segregating it entirely from A. As expected, fewer causal responses were obtained. In another version of the experiment (Fig. 19, p. 340) segregation was ensured by the fact that B had much more luminance. (ii) In **exp. 100** B was a strip which lengthened after A reached it. In one version of this experiment (Fig. 20a, p. 341) B was at the front end of A; in a second version (Fig. 20b, p. 341) it was at the rear end. In both cases there was a Screen Effect, and (since this implies separation of B) virtually no causal responses were obtained. (iii) Crabbé has shown (Fig. 12, p. 325) that if B is already integrated in a kinematic structure with A, this prevents integration with a third object, C, which joins B in the same way as does object A in the Type-experiment of launching.

(*b*) Segregation weakened. If A comprises several circles of light and B is made to lengthen from a small strip to its full size, B gives the appearance of having been in the group from the start. Also (**exp. 101**, Fig. 21, p. 343) if B is a very bright circle which suddenly appears in a position concentric with A, a larger but less bright circle, and both then move at A's original speed, 'common fate' operates from the moment

Where there are illusions of movement or illusions of causality there is clearly no physical movement or physical causality; yet since we must be seeing something, 'what' we see must therefore be phenomenal movement or phenomenal causality, and in addition a special phenomenal 'world' must be postulated in which to house them. Yet if instead of 'There is phenomenal movement' we say 'It looks as if there is movement' and the same in the case of causality, does not this whole Cloud-cuckooland disappear? To put the point another way, if dualistic language is unnecessary, then according to the principle of Occam's razor we are required to abandon it.

This, in outline, is the sort of objection which might be made to some forms of phenomenological approach. Yet as far as Michotte is concerned, such criticism is largely based on misunderstanding, at any rate if we go by his explicit statements at the start of Appendix II.[3] From these statements it is clear that his special version of phenomenology not only differs from that of philosophical writers such as Husserl but has very much more in common with neo-behaviourism than appears at first glance.

I shall attempt to show in what follows that there is nothing in Michotte's conceptual scheme to which a neo-behaviourist (or anyone else who is self-conscious about methodology) can seriously object. Although I believe that an alternative description of his work is possible which does not include any reference to phenomenology, such a description would not involve any fundamental change in research procedure but would merely constitute a different account of the existing one.

The phenomenal and physical worlds. Implicit in Michotte's usage, as he indicates on p. 306, there are in effect two senses of the term 'the physical world'. In the first sense he has in mind what is popularly called the 'external' or 'outer' world, comprising familiar objects such as chairs and tables; this 'world' is being contrasted with the 'inner' world which we are said to study when we 'introspect'. It is in this sense that his subjects, in looking, for instance, at the patterns on the discs, may be said to be studying the physical world; they claim, in other words, to be looking at something 'out there', and (except, for example,

[3] See p. 305. See also A. MICHOTTE, *Philosophie et Psychologie*, Revue Néo-scolastique de Philosophie. Editions de l'Institut Supérieur de Louvain, 39, 1936, 208–228. I am very grateful to Professor Michotte for giving me further details of his views in personal discussion.

III. TWO CRITICAL ESSAYS*

1. PHENOMENOLOGY AND SCIENTIFIC METHOD

Introductory. To many British and American readers Michotte's references to 'phenomenological' psychology and his distinction between 'the phenomenal world' and 'the physical world' may cause misgivings. As will be indicated in a moment, Michotte does in fact give a special meaning to the word 'phenomenology' in which he lays particular emphasis on the need for careful examination of the subjects' verbal reports. If the word 'phenomenology' is taken at its face value, however, and is understood to mean 'the study of perceptual experience', its use gives rise to difficulties. Thus to say that one is doing phenomenology might seem to imply that one believed in a dualism between 'physical' events on the one hand and 'experiences' or 'mental' events on the other. Koffka, for example, seems to subscribe to such a dualism when he speaks of phenomenology as being 'as naïve and full a description of conscious experience as possible'.[1] On this view it would seem that psychology has a subject-matter different in kind from that of all other sciences, viz. the 'mental' or 'phenomenal' world as opposed to the 'physical'. In contrast, many British and American psychologists have tended to have behaviouristic leanings, not indeed in the sense of accepting the classical behaviourism of J. B. Watson in all its detail, but at least in refusing to regard 'conscious experience' as their subject-matter.

Such people—whether we label them behaviourists, neo-behaviourists, or something else—may be tempted on these grounds to find fault with the conceptual scheme used by Michotte in this book. Does he not explicitly claim to be doing phenomenology, and does he not expressly distinguish phenomenal movement and phenomenal causality from their physical counterparts? Not only does he believe in 'two worlds', it seems; he even goes so far as to state that there is a high degree of correspondence between them.[2] In addition it might be said that he has been misled into using dualistic language by his study of illusions.

* I am grateful to my colleague Dr J. W. TUCKER for considerable help with this section and the following one.

[1] K. KOFFKA, *Gestalt Psychology*, Harcourt Brace & Co., New York, 1935, p. 73.

[2] See Chapter XIV, especially p. 226.

in the case of the relevant Michotte experiments there is phenomenal but not physical causality; that is to say, the subject reports a causal impression but no corresponding physical transaction is taking place. Thirdly, when a person looks at everyday causal transactions, for example, two billiard balls colliding, there is both phenomenal and physical causality; that is to say, he reports the occurrence of a causal relationship in a situation where physical work is being done. It is important to note that 'phenomenal' does not mean the same as 'apparent', if 'apparent' is being used in its commonly accepted sense of 'unreal' or 'illusory'. It is true that in the case of the phi phenomenon the movement is in fact illusory, just as in the relevant Michotte experiments the causality is in fact illusory; but 'phenomenal' and 'physical' are not mutually exclusive terms, as 'apparent' and 'real' often are, and Michotte is at pains to emphasise that where there is phenomenal movement there is almost always physical movement and that where there is phenomenal causality there is almost always physical causality. In other words, there is a high degree of correspondence between the two 'worlds'.

It should be noted that this account contains no reference to 'experiences' or 'mental events'. For Michotte such things are—from the point of view of scientific psychology—an unknown, an *x* (p. 307); and although 'events *x*' do play a part in his conceptual scheme, as we shall see in a moment, he does not regard psychology as the immediate study of such events, since indeed it is logically impossible that they could ever be observed by an investigator. His position in this respect is thus very much more similar to neo-behaviourism than it might appear to be at first glance.

The notion of a 'correspondence' between the two 'worlds', however, may still seem puzzling. Michotte's point, it seems to me, can most helpfully be expressed with special reference to vision. What he is saying is that for most of the time vision is reliable. Visual cues give a good indication of the sort of results that we might expect from examining the dial of a measuring instrument, and they thus enable the organism to take appropriate action. For example, something which according to physical measurement is a cube normally *looks* like a cube (compare p. 226), and in general the visual cues from any solid object are usually a reliable guide as to what results would be obtained if one measured its size.

What holds of vision holds also, *mutatis mutandis*, of the other

when they report degrees of assurance) not to be looking inside themselves or 'introspecting'.

His second use of the term 'the physical world' involves a different contrast and for his purposes a more important one. This contrast is between a description of the appropriate parts of his experimental procedure *in physical units* (i.e. units used in physics, such as centimetres, seconds, etc.) and an account of *what his subjects say*. The investigator thus has two sources of information and is able to study the concomitant variation between them.

It is important to note at this point that Michotte's use of the word 'world' need not be understood in any grandiose or high-faluting sense such as might imply that psychology studied two 'kinds of reality' or two 'orders of being'. Michotte's examples of 'the world of finance' or 'the world of the theatre' (p. 305) are on a par with Gilbert Ryle's hypothetical periodical, *The Poultry World*.[4] 'Septic' conclusions, for example, that because one can speak of the phenomenal and the physical world the universe must therefore in some sense be dualistic, form no part of Michotte's argument.

To illustrate the phenomenal-physical distinction we may take the examples of movement and causality. When someone looks, for instance, at the hour hand of a clock, we could apply the proposed terminology by saying that there is physical movement but no phenomenal movement. In other words it is possible to describe what is happening in terms of distance travelled per unit time, but no movement can be seen, or, more strictly, there is no mention of movement in the subject's verbal report. Conversely, in the case of the phi phenomenon there is phenomenal movement but no physical movement; in other words there is visible movement, or, more strictly, the subject reports that he sees movement, but there is no moving object whose speed could be detected by measuring instruments. On many occasions, however, when objects move within certain limits of speed, there is both phenomenal movement and physical movement; the subject reports that he sees movement and the speed of movement can be expressed in physical units. The same principles hold in the case of causality. When seed is sown and later a crop appears there is physical causality but no phenomenal causality; that is to say, work measurable in physical units has been done but there is no report of any causal impression. Conversely,

[4] G. RYLE, *Dilemmas*, Cambridge, 1960, pp. 73 seq.

states that he originally introduced the word in preference to 'sensation' which had been in common use in earlier experimental psychology, but which had been criticised by psychologists of the Gestalt school as too 'elementaristic'.[6] His intention, as he points out on p. 15, note 20, is to indicate what is reported by the subjects as being 'immediately given' in perception, as opposed to what they infer.

Now this usage is clearly at variance with certain forms of common speech. Thus 'I had the impression that he was unhappy', so far from referring to anything immediate and indubitable, indicates considerably less certainty than, for example, 'I knew that he was unhappy' or 'I could see that he was unhappy'. This of itself of course is not necessarily a difficulty, since both the *Oxford English Dictionary* and the *Grand Larousse* allow for several different senses of the word 'impression', and in any case a psychologist is not tied to usages found in the dictionary. The important point, it seems to me, is that the notion of 'stamping' gives a misleading account of what perception involves, since it implies that a hard and fast distinction is invariably possible between what is 'given' (in the sense of being 'stamped' on the receiving organism) and what is inferred; this general assumption seems to me highly questionable.[7]

Whatever the difficulties in general connected with the word 'impression', however, they do not, I think, affect Michotte's position with regard to the special case of causality. He is concerned, as he makes clear on p. 349, with the difference between knowing that causality is at work and seeing causality in operation; and this is surely a valid distinction. Thus in cases of launching and entraining the causality 'hits you in the eye', so to speak, and there is no need to look any farther to account for what is happening. Thus it is unnecessary to postulate the operation of unseen levers or springs or the interaction of unseen small particles. This holds, according to Michotte, in all cases where there is

[6] A. MICHOTTE, personal communication. The French word 'impression' covers very much the same ground as its English counterpart.

[7] The 'stamping' theory has a long and respectable history. It occurs, for example, in the writings of John Locke, who appears to want to limit the 'given' to what has a one-one correspondence with the pattern of stimulation on the retina. Thus on his view, when we look at, say, a round globe, 'the idea thereby imprinted on our mind is of a flat circle' (*An Essay Concerning Human Understanding*, Book II, Chapter 9, section 8). Even the Gestalt theorists, though they insisted that the basic datum was an organised whole or Gestalt as opposed to a mosaic of sensations, never seem to have adequately challenged the assumption that perception involves basic data of some kind.

senses. Thus, according to Michotte, there can be phenomenal causality in the tactile-kinaesthetic sphere[5]; there can be phenomenal movement in the rise and fall of musical notes (p. 247), or in the cadences of an orator (p. 284). 'Phenomenal' does not mean simply 'visual'. The contrast is between (*a*) the stimulus-system, whose properties the observer can determine by making the appropriate pointer-readings, and (*b*) the subject's verbal report as a result of this stimulus-system; and this contrast can be made irrespective of whether the stimuli are visual or of some other kind.

Illusions, as Michotte points out, are cases where the expected correspondence breaks down. They are of special interest to the psychologist since they involve the separating out of different features in the stimulus-organism-response situation and hence enable us to study each in isolation. Thus Michotte's experiments separate out the pattern of visual peripheral stimulation when solid bodies interact; experiments on the phi phenomenon have commonly been supposed to separate out the cortical conditions necessary for perception of movement independently of the original source of stimulation; and experiments on the Müller-Lyer illusion make possible the isolation of peripheral and cortical factors in judgments of equality and inequality of length. There is no question in Michotte's conceptual scheme of postulating a phenomenal world in which to house illusory experiences. For him the issue is whether the subjects' verbal responses do or do not coincide with what one would predict on the basis of physical measurement.

Michotte's use of the word 'impression'. Objection may still be made to Michotte's use of the word 'impression'.

This word has, of course, had a complicated history. In many uses an important suggestion is that of 'stamping' or 'printing'. Michotte

[5] See especially Chapter XIII. The discussion in this chapter, concerned as it is with our awareness of our own body and with voluntary action, can be regarded with no difficulty as a contribution to phenomenology, but may be thought by some to be incompatible with a behaviourist programme. The fact, however, that the structural organisation is recognised as being within the organism as opposed to outside it, as in cases of launching and entraining, raises no new difficulty of principle. The subject's 'experience' is as much an x as before, and his differential responses are being studied as much or as little as in other types of experiment. Just as the appropriate signalling system enables organisms to differentiate different features in the external environment, so—in the case of man at least—we must postulate some method of signalling by which actions where the 'I' of 'self' intervenes are distinguished from involuntary ones; and for investigation of this mechanism the subject's verbal responses are as relevant as they are for the study of any other brain mechanism.

Michotte's method can be preserved but from which the concept of 'phenomenology' has been made to disappear.

In the first place the two sources of information, as described by Michotte on p. 305, remain as before, viz. (i) the stimulus-system described in physical units, and (ii) the verbal responses of the subjects. Instead of speaking of a 'correspondence' between two 'worlds', however, one can say, if one prefers—since it comes to precisely the same thing—that vision (and in some contexts other senses) is usually reliable, or, more strictly, that the verbal reports of the subjects and the numerical properties of the stimulus-system are in a fairly consistent relationship.

Secondly, we may characterise the bulk of Michotte's work on causality as *an attempt to study the visual proximal stimuli in isolation*; the attempt is to find out, not what the subject knows about bodies in interaction, but what it looks like *visually* when bodies interact, as determined by the verbal responses.

There is, however, an outstanding difficulty. To say, as a neo-behaviourist might, that Michotte was 'really' studying only the verbal responses of his subjects when presented with particular combinations of stimuli, though true in the sense that he was not and could not have been studying 'events *x*' directly, gives no account of concepts such as 'good continuation', 'common fate', and 'ampliation of the movement'. These concepts have clearly justified themselves experimentally; and no arm-chair theorist has the right to rule them out as illegitimate on the basis of his preconceived ideas about scientific method in general.

Michotte's account of the matter (p. 308) is that the subjects' verbal responses can be used to suggest hypotheses about the structure of 'events *x*', and that the concepts in question (or similar ones) are regularly required if adequate hypotheses are to be framed. A neo-behaviourist, however, could say instead, I think, that events *x* are intervening variables, in much the same sense as 'drive', for example, is an intervening variable in Skinner's system.[8] In that case it makes perfectly good sense to study the laws in accordance with which these intervening variables operate and to introduce new concepts in the process, but one is spared the 'ontological discomfort' of having to regard events *x* as

[8] '[Drive] is defined in terms of sets of operations and of response changes. For the drive "hunger", the operations relate to various procedures involving food deprivation, and the response changes are alteration in the rate of occurrence of a variety of response [those that have to do with ingestion of food].' From the section on Burrhus F. Skinner, by William S. Verplanck, *Modern Learning Theory*, New York, 1954, p. 293.

ampliation of the movement, since it is only in conditions of ampliation that this immediateness occurs; only in these conditions can one say that A, as it moves, is bringing about the displacement of B. In contrast there are situations such as those studied by Levelt (pp. 359–361), when subjects reported braking, but did so as an elaboration of what they saw; they felt the need to make sense of what was in front of them, and a convenient way of doing so was to postulate a frictional surface which slowed the objects down, even though nothing corresponding to 'friction' was present in the stimulus-conditions.

It may still be said that there is a difficulty in the case of qualitative causality. There are many occasions in the qualitative sphere where one might be disposed to say that the awareness of causality was immediate. Many of these cases are veridical, in the sense that there is in fact a genuine causal connexion between the events, as for instance when one presses the self-starter of a car and the engine then starts. Of special interest, however, are the illusory cases, i.e. those where there seems to be a causal connexion when in fact there is not. Duncker's example (p. 16) of a light becoming lit up as a door shuts is one of these. Sometimes the illusion involves noise, as in the schoolboy game where one person pretends to slap another on the cheek but stops his hand just in time while the other claps his hands to produce the noise of a cheek being slapped. In this connexion I cannot forbear mentioning the experience of a well-known psychologist during the last war. He had just pulled a lavatory chain, and immediately the air-raid siren sounded! He assures me that in this case the apparent causal connexion was positively alarming. These examples are admittedly anecdotes, and according to Michotte it is very difficult to produce comparable situations in the laboratory (see pp. 235 seq.); but on the basis of common experience is there not a case for saying in such cases that the awareness of causality is as immediate as it could be? In all the situations cited, however (except for the cheek-slapping case, which Michotte would presumably classify as an illusory example of 'impact-noise'), it is necessary to postulate the operation of hidden electrical or mechanical devices—switches, levers, etc.; and it is because these cases are different in this important respect from cases involving ampliation of the movement that Michotte has chosen not to use the word 'impression' in referring to them.

Structural laws and intervening variables. I want finally to suggest that a conceptual reformulation is possible in which the essentials of

the conclusions reached, it would be a misunderstanding to suppose that the issue can be settled simply by carrying out appropriate empirical tests. In contrast psychological questions, in so far as they can be settled at all, are such as must be settled by empirical means, that is, by the study of behaviour or more specifically by the phenomenological methods described in the preceding section. Examples would be 'How does the idea of causality originate in the child?' and 'What are the necessary and sufficient conditions for a causal impression to occur?'

Philosophical issues. Michotte expressly states that he is in no way challenging Hume's philosophical position.[10] Indeed, he agrees that as far as the physical sciences are concerned Hume's account of causality is not in question. This is to say in effect that the phenomenal or Gestalt properties of objects are of no interest to the chemist or physicist. Thus the fact that the stars which go to form Cassiopeia or the Great Bear form clusters, and the fact that billiard balls when they collide give rise to a special kind of visual impression, while of extreme interest phenomenologically, are simply irrelevant as far as chemistry and physics are concerned. Michotte is surely right here, and indeed there are no conflicting claims which require to be settled.

The question arises, however, as to whether—despite his cautious disclaimers—Michotte's findings can legitimately be made the basis for an attack on Hume's account of the concept of 'cause' or can solve any of the difficulties arising from it. This is a complex subject; but the following points seem to me relevant and important.

(*a*) If we want to claim that the statement 'Event X is the cause of event Y' is always interchangeable with the statement 'If an event of type X occurs, then regularly an event of type Y occurs', we are forced to agree that day is the cause of night and night the cause of day. This move is explicitly made by Russell[11]; but those who claim to find it uncomfortable could well argue that Michotte's work gives them additional support, since, in Michotte's terminology, day and night are not integrated in the requisite structure to give rise to a causal impression.[12]

10 See especially p. 6 and p. 256.

11 *Mysticism and Logic and Other Essays* (Longmans, Green, and Co.), London, 1921, p. 193 (reproduced in Pelican Books, 1953).

12 Nor in this case are there any unseen mechanical actions such as we assume to occur when we claim that sowing the seed is the cause of the later appearance of the crop. Compare p. 257 of this book, and Hume, *A Treatise of Human Nature*, part III, section ii.

'real existents', since this is agreed to be unnecessary in the case of intervening variables.

It is worth adding that Michotte's approach is as 'operational' as any neo-behaviourist could wish for, since the operations involved in setting up the stimulus-conditions are clearly specifiable in all cases, and, as for the responses, there are obvious criteria for recognising whether they are 'causal' or whether they are not.

In practice Michotte's conceptual scheme and this 'neo-behaviourist' formulation with its intervening variables involve precisely the same experimental procedures, and in that sense the choice between them is arbitrary. Michotte's system is admittedly incompatible with any version of behaviourism which takes no account of laws of structural organisation; but in allowing that the ultimate justification for speaking of 'the phenomenal world' lies in the study of the subjects' verbal responses, Michotte can fairly be said to have gone to meet the behaviourists half way.

2. MICHOTTE'S EXPERIMENTS AND THE VIEWS OF HUME

Introduction. It is sometimes said that Hume's discussion of the notion of cause is conceptual in character, and that Michotte in appealing to the result of experimentation in his criticism of Hume has misunderstood him and is guilty of arguing at cross-purposes.[9] This criticism, although it does not seem to me fully justified as it stands, at least calls for a clear statement of the issues at stake; and in what follows I shall attempt to separate out some of these. My general purpose will be to examine how far Michotte's findings are relevant to what was said by Hume, and to consider in what sense, if at all, they constitute a refutation of him.

At the outset we need to distinguish philosophical questions about causality from psychological ones. Perhaps the most helpful way of characterising the former is to say that they are concerned with theory of knowledge and with rules for the operation of concepts. Examples of such questions are, 'What grounds have we for saying that a particular effect must necessarily follow from a particular cause?' and 'Can sentences containing the word "cause" be replaced without loss of meaning by sentences containing the words "if . . . then"?' In these cases, although empirical evidence may be relevant in one way or another to

[9] See, for instance, D. W. HAMLYN, *The Psychology of Perception*, Kegan Paul, 1957, pp. 76 seq.

poral relations are all-important.[14] It is therefore not surprising that in the absence of this structure we are hesitant to speak of the cause-effect relation at all. In the light of Michotte's phenomenology the so-called 'convention' that 'X was the cause of Y' entails 'X occurred earlier than Y' thus ceases to be puzzling.

Psychological and phenomenological issues. Where Michotte claims to be challenging Hume is on the phenomenological issue. According to Michotte, Hume did not believe that there was such a thing as the causal impression,[15] whereas his own claim is that such an impression regularly occurs whenever certain conditions of speed, time, etc., are satisfied.

It is not entirely clear, however, that this is a genuine disagreement. One way in which Michotte expresses his claim is by saying that 'There is actual perception of causality'.[16] If for purposes of discussion we limit ourselves to the case of vision, this amounts to saying that we *actually see* causality. Now a Humean, even one who had taken part in Michotte's experiments, might still dispute this conclusion; all that can actually be seen, he would say, is two separate movements. The reason for talking in this way is that 'I can see an X' entails in ordinary speech that an X is really there, and since all that is really there is two movements it is impossible as a matter of logic that we should see anything else. Now clearly this is not to dispute the phenomenology of the situation; and confusion may arise if the argument changes from being a phenomenological one to being a conceptual one without the participants realising it. What sort of accusative can appropriately follow the verb 'see' is a conceptual point, and indeed in this context a somewhat trivial one. Such an accusative is agreed by both parties to stand for something 'really there'; but provided the phenomenology of the situation is not in dispute it is hard to see what useful purpose is achieved by discussing whether or not the causality is 'really there' in addition to the two movements, or indeed whether any Gestalt property of a situation is 'really there' in addition to the parts considered in isolation. Michotte's example of the knife and the loaf[17] brings out this point even more clearly. One can scarcely suppose that if a person says that all we really see is a moving knife and a static loaf, it follows that the situation looks different to him from what it does to the rest of us. A case can admittedly be made for saying, as a conceptual point, that we do see

[14] See especially his remarks on the hierarchy of priority, pp. 66 seq.
[15] See p. 225.
[16] See p. 87.
[17] See p. 15.

Indeed the whole programme of translating 'cause'-sentences into 'if . . . then'-sentences is justified, if at all, only from the point of view of those not interested in perceptual organisation. Michotte's research brings home to us that in ordinary speech we are hesitant to use the words 'cause' and 'effect' unless the two events are linked in some kind or perceptual organisation from among those described in this book (or unless some hidden mechanism is postulated which, if visible, would give rise to a similar perceptual organisation). If a philosopher proposes a conceptual innovation as a result of which the occurrence of this or that perceptual organisation is no longer deemed a criterion for the correct use of the word 'cause', he is entitled to do so; but he cannot any longer claim that it is the plain man's concept of cause which he is discussing. This conceptual point could, of course, have been made simply from consideration of causality as it occurs on the cinema-screen; Michotte's experiments are not in that sense indispensable to the argument, but they add weight to it since they show in a systematic way that visual information can be studied in isolation from the information obtainable by physical measuring devices. It was necessary for Michotte to produce *illusions* of causality to ensure that his subjects made use of *vision only*; he wished to find out whether there was a visual impression of causality, not whether his subjects thought that mechanical work was in fact being done. In this respect the philosophical relevance of Michotte's work is to add weight to a conceptual point which could have been argued for independently.

(*b*) On Hume's account one tends to be puzzled by the fact that the word 'cause' is applicable only to the earlier of two events. Thus Dummett writes: 'On the ordinary Humean view of cause, a cause is simply a sufficient condition. . . . But obviously we can also observe that an event of a certain kind is a sufficient condition for an event of another kind to have taken place previously; and why should we not then call the later event the "cause" of the earlier? . . . It now appears as though it were a straightforward defining property of a cause that it preceded its effect. This, however, seems too facile an explanation. Why should we lay down temporal precedence as a defining property of cause?'[13] Now Michotte's work brings out that in a large number of cases what we call the cause is phenomenologically linked with its effect in the kind of structure which he has described—a structure in which tem-

[13] M. A. E. DUMMETT, 'Can an Effect Precede its Cause?', *Aristotelian Society*, Supplementary Volume XXVIII, 1954, pp. 27–8.

what is the correct interpretation of Hume. It is always possible, as Kant has pointed out, to understand a philosopher better than he understood himself[21]; and as a result it is very easy to make the move from 'This is what so-and-so might have said or ought to have said' to 'This is what so-and-so really meant'. Nowadays we think of Hume as a philosopher; and it may well be that from our point of view we feel like saying that Hume 'ought' to have been discussing conceptual matters, not phenomenological ones. This 'ought' is dangerous, however, since there can be no doubt that Hume's formulations are so worded that at least they *seem* like phenomenology; he certainly *seems* to be denying that a causal impression in Michotte's sense ever occurs, and this is the interpretation put on him not only by Michotte but by many other psychologists in the same tradition such as Claparède and Köhler. From the point of view of modern psychology, however, disputes as to the correct interpretation of Hume cannot be regarded as of major importance. Moreover, we should remember that the distinction between conceptual and phenomenological issues was one which Hume never made, and the situation created by Michotte in which visual stimuli are studied in isolation was one which Hume never considered. What he would have said if these points had been put to him can be no more than a matter of historical speculation. In the absence of any means of questioning him it is at least not unreasonable to interpret him phenomenologically; and Michotte insists that it is only in so far as Hume is talking phenomenology that there is any serious disagreement between them.

Finally, there is the problem of the psychological origin of the idea of causality. On this issue Michotte seems to me to be on particularly strong ground. Not only is there a *prima facie* case in his favour from the very fact that, unlike Hume, he performed systematic experiments; in addition he has clearly shown that habit and expectation are not the crucial factors in giving rise to a causal impression. If the stimulus-conditions are right, according to Michotte, the causal impression occurs (provided there is a sufficient degree of maturation) almost invariably first time off, whereas if the stimulus-conditions are wrong it does not occur however often the experiment is repeated. Hume's appeal to habit and expectation is thus psychologically incorrect.

[21] I. KANT, *Critique of Pure Reason*, Transcendental Dialectic, Book I, section i.

causality, i.e. for treating the word 'causality' as a suitable accusative for the verb 'see'; this way of talking is convenient in research such as that of Michotte since it indicates unambiguously the nature of the visual signal, viz. that it is the same when the subject looks at the discs as it is when physical work is being done by one object on another. Similarly, one could argue that in the case of the phi phenomenon we 'actually see' movement, on the grounds that the cortical pattern produced by the visual stimuli is the same as when physical movement is taking place. All such argument, however, is conceptual in character; and there is no obvious absurdity in agreeing that phenomenologically a causal impression in Michotte's sense sometimes occurs, while refusing to say that we 'actually see' causality.

Now some scholars would say that Hume is doing just this, that he knew perfectly well what it looks like when two billiard balls collide, and that he was not disputing the existence of a causal impression in Michotte's sense.[18] His problem, on this view, was the *justification* for regarding one event as cause and another as effect; and the passages cited by Michotte[19] with a view to proving that he did not believe in the existence of a causal impression require a different interpretation. Thus, when Hume says that we can never 'by our utmost scrutiny discover anything but one event following another' and that ''Tis vain to rack ourselves with further thought', this should be understood as meaning that further scrutiny or further thought cannot justify the claim that two events stand in a cause-effect relationship—a philosophical point, not a phenomenological one at all.

Michotte, of course, says that Hume adopted 'an analytical attitude',[20] and he claims that the characteristically Humean situation is the one which his subjects describe as 'two separate movements' (i.e. where there is an appreciable time-interval between the arrival of A and the departure of B). If the above interpretation is correct this could not have been what Hume meant; and indeed one cannot exclude *a priori* the possibility that some subjects when presented with an experiment of launching or entraining might claim to 'see two movements' not through adopting an 'analytical attitude' but because they chose to use the word 'see' in a different way.

It is dangerous, however, in my opinion, to be too dogmatic as to

[18] Compare D. W. HAMLYN, op cit., p. 77: 'Hume's thesis is compatible with the thesis that in some sense of the word "impression" we do have an impression of causality.'

[19] See pp. 255–256. [20] See p. 256.

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Index of Subjects

Where a subject has a particularly important section devoted to it, the first page of that section is given in heavy type. Otherwise page-numbers indicate the start of the passages which are likely to be of most interest for any given subject. Complete references would have made the index almost unusable.

No references are given to the description in Chapter II of how the different pieces of apparatus were constructed, since the chapter is sufficiently short to make this unnecessary. The same applies to the four summaries and the Commentary.

(The label (G) by a word indicates that that word is given in the glossary.)

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The following further authors are cited in the *Commentary* only: